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# MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor.

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## CONCERNING NORMALS, SECULAR TRENDS AND CLIMATIC CHANGES.

By CHARLES F. MARVIN, Chief of Bureau.

[Weather Bureau, Washington, D. C., Sept. 12, 1923.]

Is the climate changing? This question, so frequently asked, may be answered "Yes" or "No" with equal propriety, depending upon the particular point of view. Geological records leave no question whatever that very great changes of climate have occurred in the vast lapse of time covered by the geological ages of the past. On the other hand, no conclusive evidence can be found to prove that any material or notable *permanent* changes for the globe as a whole have occurred during the several thousand years of authentic human history. That is to say, no data are known which prove, nor have we any good reason to believe from all that *is* known, that the climate of the globe is systematically or permanently different at the present time from what it was 6,000 years ago.

Notwithstanding these unequivocal affirmative and negative answers to the question "Is the climate changing?" the present writer is inclined to believe that important long-time fluctuations of climatic conditions have occurred and that minor surgings of the seasons to and fro can and do take place and prevail over restricted regions for relatively long periods of time like 50 or 100 years.

Conservative climatologists do not, in principle, subscribe to these views, perhaps, and while marked fluctuations of several years' duration are admitted, nevertheless it is the common belief that a seeming systematic departure from normal of one kind is quite soon offset by a like departure of the opposite kind, and that the *normal* state is more or lesss steadily maintained. It is believed the evidence submitted in what follows will help to show that such views are more or less incorrect and will tend to justify the deep-seated conviction in the minds of a great many keen observers of mature years that weather conditions at the present time differ in material ways from corresponding conditions easily within their memory. Our fathers and grandfathers, and their forefathers, probably entertained like convictions, and while memory and personal impressions can not be accepted as safe guides to questions of facts of this character, it is probably wrong to assume that such generally prevalent convictions are fictions of the imagination and quite without foundation of fact. Indeed, it seems that exact statistical methods may disclose hitherto unsuspected changes in climatic conditions which the conventional methods of analysis do not reveal, and consequently there may be some foundation of fact in the ideas of the oldest inhabitants on the subject.

In order that the writer may not be misunderstood, however, it may be proper to state that the changes here recognized as possible are not permanent, but are simply marked abnormalities which trend steadily in one direction and for many years away from that unchanging constant thing we may call the absolute normal climate. It is a mistake also to suppose that all the major features of what we call the climate of a place can be comprised or experienced within such supposedly long periods of time as, say, 50 or 100 years. We must recognize, rather, that several hundred years of records will be required to really establish the essential characteristics of the climate of a given place and period.

These views are some of the conclusions reached by the writer in the course of a series of studies upon the subject of the "Laws of sequence of weather conditions."

*Normals.*—By universal practice and accord among meteorologists, the term *normal* as applied to climatic data is defined by the equation—

$$N=\frac{a_1+a_2+a_3+\ldots\ldots a_n}{n}=\frac{S}{n} \qquad (1)$$

in which $S$ is the sum of a large number, $n$, of homogeneous observations, $a_1$, $a_2$, etc., of equal weight. Just what is meant by the expressions "a large number," "homogeneous and of equal weight" is pretty well understood though rather difficult to specify, nevertheless the significance of the terms will be briefly analyzed.

*A large number.*—No one has ever satisfactorily specified just what constitutes a "large number" within the meaning of the definition. It is obvious, however, that in climatology, at least, mere number of observations alone is not sufficient, but, rather, that *many years of time* must be embraced by the whole series of observations before it will fairly include all the essential climatic features and serve the purpose of fixing a true or absolute normal. On the other hand, many will regard a record of, say, 50 years as very long and will point to the insignificant change in the value of $N$ which results when observations for several more years are added. These conflicting considerations impel the writer to favor some looseness in defining the word *normal*, so that the mean or average value of 30 or 40 years, for example, of good data could very properly be designated a "normal," reserving the expressions *true normal* or *absolute normal* to refer to the arithmetical mean of several hundred years of data. Insistence upon the rigorous definition simply operates to eliminate the familiar word *normal* from legitimate usage or, rather, popular usage will define the word as it pleases in spite of the *ipse dixit* of the professionals.

In this connection it must be recognized that in general a value of $N$ becomes very nearly a constant when derived from 40 or 50 years of record. This is due entirely to arithmetical causes, and if we are to attach some kind of magic significance, as is generally done to the concept of *a true normal* we must at the same time place great

importance upon very small changes in its value. The real truth is the "normal" is simply a ratio between two numbers, both of which increase steadily as the length of a series of observations increases, so that the ratio soon becomes to all intents and purposes a *constant* which undergoes small fluctuations but the chief useful purpose of which is to serve as a base number with reference to which climatic fluctuations and changes may be analyzed and examined. Any arbitrary number whose value is near the average of a fairly long record is just as useful and just as significant as the supposed magic or true normal, the exact value of which can never be accurately known, and even if known would be less convenient to employ than a simple base number of nearly the same value.

*Homogeneous and of equal weight.*—While the import of these terms is essentially different, they are so closely related as to permit them to be considered together in this brief analysis. Strict homogeneity and equality of weight are simply unattainable, especially in long meteorological records, either for a single locality or for some considerable unit area. Such records necessarily comprise many breaks, discontinuities, changes in instruments, locations, exposures, observers, and even in the stations and surface conditions themselves. The deepest and first concern of the climatologist and statistician is to secure at the outset of any investigation the highest approach he can to homogeneity and equality of weight in the data employed. At the best some faulty values remain and appear as abnormalities, false fluctuations, or seeming climatic changes which can not be satisfactorily eliminated and cause much uncertainty in conclusions and interpretations.

*Accumulated sums of departures.*—Recognizing from all that precedes that there is no magic significance to the concept *normal* and that a simple base number conveniently near the average of 30 or 40 years of data answers all practical purposes as a reference base, the question at once arises, what methods are best for analyzing and disclosing secular trends and climatic changes?

The chief purpose of this paper is to develop and present a method which has long been familiar to many in the Weather Bureau, but of which very little and unimportant use has been made.[1] It seems appropriate and convenient to designate the process *the method of accumulated sums of departures*. In 1886 the Weather Bureau began to compile in its original records the accumulated daily departures of temperature and precipitation since January 1 of each year, using the best normal or base values then available from not over 16 years of observations. This tabulation is being continued at the present time, but fails to serve any particularly useful purpose, because, first, the accumulation runs only for each calendar year separately, but a more serious complication arises because the normal or base number has changed from time to time. This latter makes it impossible to easily derive the accumulated sums for long periods of time. The writer has found by trial that these accumulated sums (abbreviation *A. S.*) are wonderfully significant of secular trends and climatic changes, as will be more fully shown in what immediately follows:

*Theory of accumulated sums.*—Some confusion will be avoided in presenting the elemental theory of *A. S.* if only *annual* values of data are first considered, because this does not require any consideration of the well-known seasonal or annual changes which are such striking features of temperature and to a less extent of other meteorological elements. Accordingly, let $B$ be a true normal annual value or, more conveniently, any arbitrary unchanging simple number nearly equal to the average of 30 or 40 years of any climatic data. Any single yearly value of the data, $a_1$, for example, gives rise to the equation

$$a_1 - B = d_1$$

in which $d_1$ is the familiar departure from normal or base, and in like manner any long record may be transformed into or replaced by a series of values or departures $d_1$, $d_2$...., thus:

TABLE 1.—*Illustrating computation of accumulated sums for annual data.*

| Date. | Data. | Base. | Departure. | $\frac{A.S.}{y}$ |
|---|---|---|---|---|
| .... | $a_1-$ | $B=$ | $\pm d_1$ | $d_1$ |
| .... | $a_2-$ | $B=$ | $\pm d_2$ | $d_1+d_2$ |
| .... | $a_3-$ | $B=$ | $\pm d_3$ | $(d_1+d_2)+d_3$ |
| .... | . . . | . . . | . . . | . . . . . |
| .... | $a_n-$ | $B=$ | $\pm d_n$ | $\pm \Sigma d$ |
| | $\Sigma a -$ | $nB=$ | $\pm \Sigma d$ | (2) |

Now, the universal impression seems to prevail that if the value of the base number $B$ is reasonably close to a true normal value, then the sum of the departures *A.S.* tends to be zero—that is, directing attention to the last column the values of $y$ therein will never become very large nor ever long remain continuously of the same algebraic sign, but that the signs will change with comparative frequency and the magnitudes of $y$ remain comparatively small. A very few trials by calculating $y$ for reliable long records will show at once that the facts are very different from the impressions expressed above. Moreover, a diagram of the values of $y$ in the above table, plotted against dates as abscissae, is most useful and instructive. Attention is invited to the following striking properties of the above table and diagram of $y$.

In the table above

(1) Any value of $y$ in the table divided by the number of observations it comprises gives a quotient which, added to the base number $B$, is the normal or average value of the data for the length of the record up to that date.

(2) In a similar manner, dividing the algebraic difference between any two values of $y$ in the table by the number of observations comprised, and adding the quotient algebraically to the base number gives the average value of the data over the period of record embraced.

The diagrams in some cases show prolonged and striking trends of the values of $y$ away from the adopted base line, and it is plain from the properties designated (1) and (2) above that the slope of a straight line from the origin to any point on the curve gives the average value of the departure over the period covered. In like manner, the slope of a line between any two points of the diagram gives again the average value of the departure between the dates represented. A very little trial and use of this method of accumulated sums will show its striking superiority over customary methods for disclosing secular trends and many important characteristics of meteorological data.

It is often easy to pick out from the values of $y$ as shown by either the table or the diagram of certain kinds of data, times when the secular trends have maximum, minimum or other significant values which are more or less steadily maintained for 50 or 100 years.

[1] While this article was in the hands of the printer, the writer's attention was called to the publication of diagrams of accumulated sums of departures of temperatures from normal by Dr. P. H. Dudley of the New York Central Lines in a leaflet entitled "Forcast for 1922–1923." This use appears to have started in 1921.

In the illustration utilizing *annual* values of any element, a constant unchanging value for the base number or normal suffices. However, whenever it becomes necessary to analyze daily, weekly, or other values affected by the annual period we must obviously employ the best daily, weekly, or other fixed normals available. In these cases it will rarely, or never, be necessary to extend the *A. S.* beyond the period of a single year or even of a season, so that exactitude in the daily or other values of the normal used may not be very consequential, nevertheless if comparisons are extended over many years and the analysis is carried out to important details, the base numbers or normals used must be homogeneous and uniform over the whole period.

It is plain in all cases where a changing value of the base number $B$ is necessary, that equation (2) must be written [1]

$$\Sigma a - \Sigma B = \pm \Sigma d \qquad (3)$$

The broad utility of the method is in no sense limited either to meteorological data on the one hand or to the disclosure of striking cases of abnormal secular trends and the fixing of epochs of marked changes in climatic characteristics. Any body of statistical data running through a more or less continuous sequence is subject to critical analysis by this scheme. Furthermore, the method may be used with great success to check up the accuracy of doubtful and inconsistent records by comparisons with other known standard data or with group averages or data for considerable areas of a standard or representative character.

Finally, the method surpasses all others known to the writer for establishing secular trends accurately, both as to the length of time a given trend prevails and also the quantitative measurement of the trend.

As all statisticians recognize, the elimination of secular trends is the most important, if not the first necessary step in any serious study of periodic recurrences and the laws of sequence of natural and economic phenomena.

*Applications to actual data.*—Naturally one's interest is chiefly centered upon long records, and the results given below will serve to indicate some features of climatic changes not hitherto recognized, as well as show the general utility of the method.

New England furnishes some of the best and longest meteorological records available within the United States. Perhaps the oldest is the rainfall record begun in a summer of severe drouth in 1749 by Prof. Winthrop at Cambridge, Mass.

Annual values by this record are continuous from 1750 to 1774, inclusive. After a gap of two years values for 1777 and 1778 are available at Watertown. Five years later a record began at Andover, some 20 miles nearly northwest from Boston, and continued until the close of 1786, with occasional annual values thereafter. The year 1792 marks the beginning of two closely accordant records at Charlestown, very near Boston, and Stow, about 25 miles to the west, which ran unbroken until about 1804. A long gap of 13 years then follows before observations became finally continuous in the immediate vicinity of Boston with the records of Dr. Enoch Hale, 1818 to 1822, and of Jonathan P. Hall, 1823–1865, and maintained thereafter at many stations.

[1] *Note to computers.*—In forming the values of $y$ in Table 2, an error made in any single value, either of a departure or the *A. S.* is carried forward in all following computations of $y$. It is, therefore, imperative to check the accuracy of both the departures and the computations of $y$. This is done at a single operation by direct computation of occasional values of $\Sigma d$ by the use of equation (2) or (3), as the case may require. In general, the sums of the observations must be computed in any case, and if done on a listing machine subtotals after each fifth or tenth item serve for rapidly checking the calculation of $y$ as the work progresses.

*Estimation of missing data.*—For general purposes it seems possible to the writer to bridge the gaps in this long record and thus draw conclusions concerning precipitation in the vicinity of Boston for a period of 173 years, from 1750 to date. This is done in the following manner:

Only two assumptions can be made concerning missing data. In a general way, missing values must be *conformable* to or *nonconformable* with observed values for periods of time before and after the missing intervals. When no other *prima facie* evidence is available than the discontinuous record itself, no reasonable assumption can be made other than the one that the missing data averages about the same as the observed values before and after. For simplicity we may designate this the *rule of conformity*.

Let us see how this principle applies in the present case. We have—

| | Inches. |
|---|---|
| Average annual precipitation for 25 years, 1750 to 1774 | 40.41 |
| Average from broken record for 20 years at Andover, Watertown, and Stow, covering period 1777 to 1804 | 41.41 |
| Average for 32 years from 1818 to 1849, a composite record of from 3 to 5 stations near Boston | 40.40 |
| General mean | 40.78 |

In the face of these almost identical averages, why may we not confidently say the rainfall during the missing years must have averaged about 40 inches?

The greatest doubt arises with reference to the missing period of 13 years, from 1805 to 1818. By good fortune an excellent record begun at New Haven, Conn., in 1804, covers this whole period. From it we have—

| | Inches. |
|---|---|
| Average annual precipitation at New Haven, 1805 to 1817 | 44.91 |

The Rodman record, begun at New Bedford, Mass., in 1814, also gives—

| | Inches. |
|---|---|
| Average annual precipitation, 1814 to 1817 | 42.83 |

Finally, the Rodman record and the Boston record, from 1818 to 1849, give averages as follows:

| | Inches. |
|---|---|
| Average annual rainfall New Bedford, 1818 to 1849, 32 years | 44.84 |
| New Haven, broken record 1818 to 1849, only 10 years | 44.74 |
| Boston for 1818 to 1849 | 41.01 |

From these results, by the familiar *rule of comparison*, Boston received less rain by 3.78 inches on the average than New Haven and New Bedford. This rate, deducted from the New Haven record during the missing years of the Boston record, gives $44.91 - 3.78 = 41.13$ inches. The practical identity of this amount with 40.74 inches, the amount of rain estimated by the *rule of conformity*, seems to leave no reasonable ground for opposing the use of the rule in a case like this to fix the average amount of rain which fell during the years observations were missing.

Probably few will reject the foregoing conclusions, but many will hesitate to follow the writer in the next bold attempt to approximate to the annual values for the individual missing years. We might, of course, fill the gaps by inserting the *average* value in each of the missing dates. This would preserve the average, but is obviously quite irrational. The following appears to be a better plan:

There are 77 actually observed values of annual precipitation in the 100 years from 1750 to 1849. Thus there are 23 years of record missing. These fall in four groups of 2, 3, 5, and 13 years, respectively. I wrote down the 77 observed values on bits of paper of exactly the same size and drew out 23 times in succession, returning the number and vigorously mixing up the

papers before each drawing. The numbers drawn were entered successively in the gaps of the record.

| | Inches. |
|---|---|
| Average of the 23 numbers drawn | 40.01 |

Here, again, the close identity of this average to the number 40.74, indicated by the *rule of conformity*, allows very little ground for rejecting the *drawings* as fair approximations to the general rain for the missing years. The writer offers no defense here for this rather bold but still logical scheme for tentatively bridging over gaps in this valuable record for 173 years.

The individual values, of course, have no significance whatever, but they serve a useful purpose in forming a continuous series of departures in Table 2, which preserves the general average trend, and the sequel will show that the main final conclusions are in no way affected by the detailed values secured from the drawings. The only possible question involved is whether the *rule of conformity* is a safe guide.

While considering here the *rule of conformity* and the method of *drawings* outlined in the foregoing for supplying missing data in justifiable cases when no other evidence is available, it may be appropriate to remark that the process of drawing is very nearly equivalent to inserting, for the missing value, a most probable value inferred from the values which have been observed. Such a value is better than to insert the normal or average value in the case of missing data, or to follow a method commonly practiced, when one or two days are missing from a month's record, of using the average value for the month as that derived from the days on which observations were taken. This in effect affirms that the missing values were equal to the average of the observed values.

The grand average of all the observations, including the 23 values drawn from the cup is 41.78, and we use the convenient base number 41.8 for computing departures and the values of $y$ as given in the table 2 and shown in the graph. Figure 1.

This diagram and the important facts disclosed by it are the real objectives of this study.

The conspicuous features which appear in diagrams of accumulated sums of departures are, first, the prolonged secular trends as shown by the straight lines O B, or A B and B C. Second, the points A, B, C seem to mark important epochs when climatic changes set in.

While Prof. Winthrop was prompted to begin his early record in 1749 because of a state of severe drought at the time, nevertheless, for the next 9 years the average rate of rain amounted to over 45 inches per year, attaining the point $A$ on the diagram. How interesting and instructive it would be if we only had the complete record back, say, to 1700! It might then appear the point $A$ really marked an epoch of climatic change, when the average rate of rainfall changed to a value of 40 iuches or less per year, as indicated by the dotted straight line A B, and that a higher rate had prevailed for many years prior thereto.

From the foregoing it appears that each reasonable assumption we make leads to the unequivocal conclusion *that the rainfall in the vicinity of Boston for 90 to 100 years prior to 1850 averaged 40 to 40.5 inches per year.* The years 1846 to 1849 seem to mark a climatic epoch in precipitation after which for a period of more than 50 years the rainfall averaged about 44.7 inches per annum.

The point $C$ appears to mark the close of this epoch with the year 1903, and the 20 years of record thereafter seem to show the beginning of a new secular trend of rainfall at a diminished rate of about 40 inches per annum. Our present knowledge affords no safe ground either to conclude surely that 1903 is one of the climatic epochs like $B$, or that the average annual rainfall for the immediate vicinity of Boston is destined to be about 40 inches for a number of years in the future.

The features of this diagram have been discussed at some length because it illustrates the possibilities of the method of accumulated sums to disclose and evaluate secular trends accurately, and to fix the dates of what for lack of a better name we have designated epochs of climatic changes.

It is perfectly obvious, of course, that the use of straight lines and their intersections to define secular trends and to locate epochs of change are only crude approximations in lieu of some appropriate curved line whose character is as yet quite unknown.

In order to answer the obvious question, what do other records show? We have built up a different 173-year record by uniting the above Boston record up to 1804 with the long records available at New Haven, New Bedford, Providence, New York City, Albany, and other places which together furnish 10 almost uninterrupted records after 1849. While this record includes the three groups of 2, 3, and 5 years interpolated by drawings, the interpolation of 13 years and all others are wholly unnecessary. While Boston is represented in the group of 10 stations, only a single record is included, which of course has a weight of only one-tenth in the average annual values.

For the values of $y$ from these data, see Figure 2. Although the data are necessarily identical in Figures 1 and 2 from 1750 to 1804, the two diagrams are otherwise mainly alike in major features, which goes far to prove the actual occurrence of an epoch of climatic change about 1849, when a low rate of annual precipitation of about 41 inches per year gave place to a wetter period for at least 50 years, with 45.4 inches per annum, or an increase of 10 per cent, in the annual rainfall. Furthermore, the feature $C$ appears in both diagrams at 1903, as if another change to a future secular trend with diminished rainfall then set in. The point B′ at 1804 marks the junction of the single record at Boston with the composite records beginning with New Haven, Conn., and including shortly thereafter New Bedford, Mass., then Albany, New York City, Lowell, Mass., Providence, and others, so that the complete number of 10 stations was reporting before the epoch 1849.

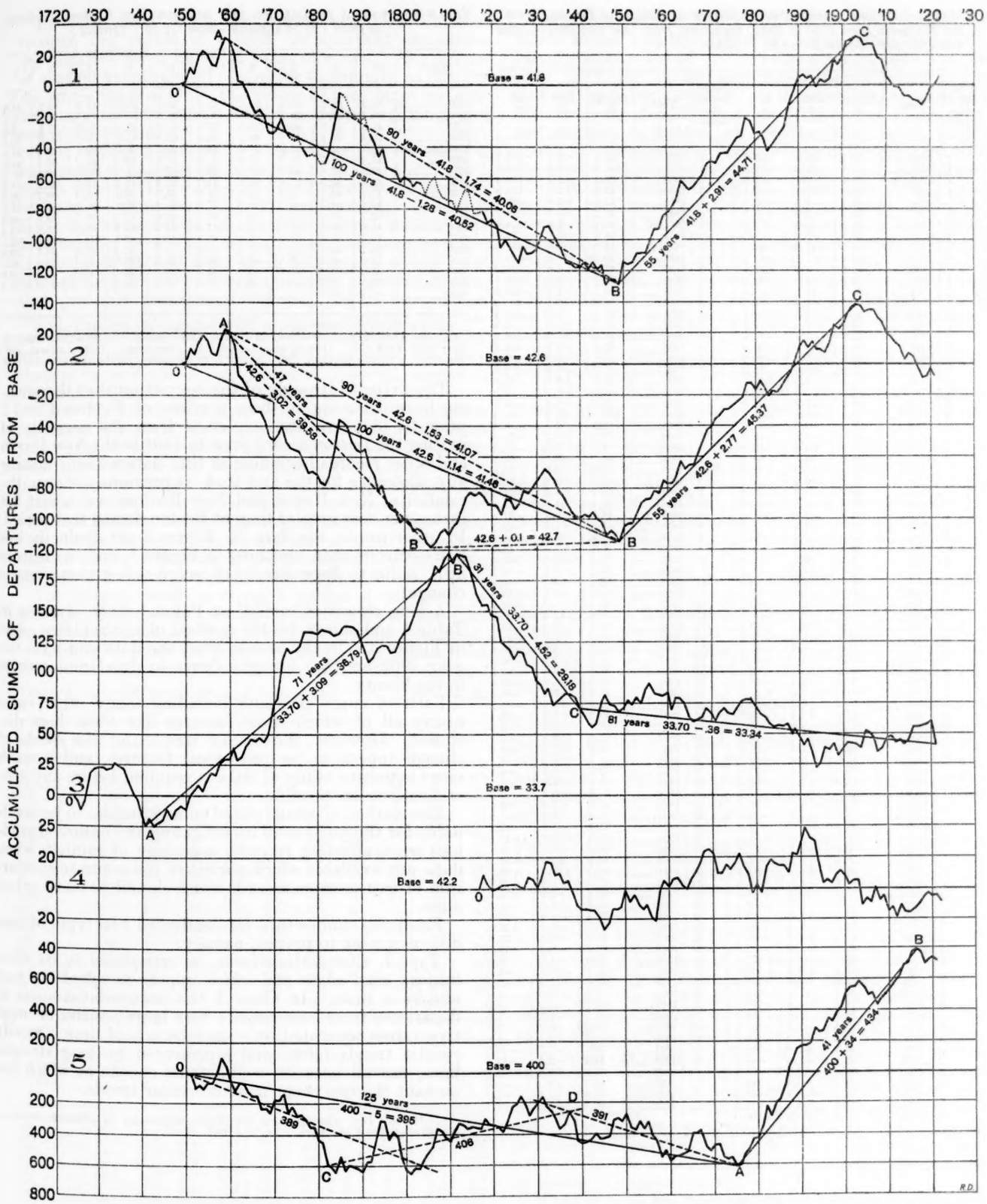


FIG. 1.—Annual precipitation at Boston and immediate vicinity for 173 years (1750–1923). FIG. 2.—Precipitation over southern New England at 1 to 10 stations for 172 years. Grand average 42.55 inches. $y$ Accumulated sums of departures from base. FIG. 3.—192 years of precipitation at Padua, Italy. Accumulated sums of departures from base, 33.70 inches. FIG. 4.—Precipitation at Marietta, Ohio, 1818–1922. Accumulated sums of departures from base, 42.20 inches. FIG. 5.—Winter precipitation at 10 stations, southern New England. Ratios to annual $\frac{\text{November, December, February, March}}{\text{year}}$ 1000. (CORRECTION: A prime was inadvertently omitted from the B near the intersection of the coordinates 1800 and 120, figure 2. Should read B′.)

TABLE 2.—*Annual precipitation in immediate vicinity of Boston, Mass., for 173 years from 1750 to 1922, departures from base and accumulated sums thereof—Base=B=41.8.* (*Inches.*)

| Number of stations. | Year. | Precip. R | R-B d | Σd y | Number of stations. | Year. | Precip. R | R-B d | Σd y |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1750 | 42.2 | +0.4 | +0.4 | 3 | 1837 | 34.1 | −7.7 | −114.5 |
| 1 | 1751 | 53.1 | +11.3 | +11.7 | 3 | 1838 | 40.3 | −1.5 | −116.0 |
| 1 | 1752 | 38.0 | −.38 | +7.9 | 3 | 1839 | 39.4 | −2.4 | −118.4 |
| 1 | 1753 | 52.0 | +10.2 | +18.1 | 3 | 1840 | 43.3 | +1.5 | −116.9 |
| 1 | 1754 | 46.5 | +4.7 | +22.8 | 4 | 1841 | 42.6 | +0.8 | −116.1 |
| 1 | 1755 | 38.5 | −3.3 | +19.5 | 5 | 1842 | 39.2 | −2.6 | −118.7 |
| 1 | 1756 | 35.5 | −6.3 | +13.2 | 5 | 1843 | 46.1 | +4.3 | −114.4 |
| 1 | 1757 | 41.3 | −0.5 | +12.7 | 5 | 1844 | 36.6 | −5.2 | −119.6 |
| 1 | 1758 | 53.7 | +11.9 | +24.6 | 5 | 1845 | 44.6 | +2.8 | −116.8 |
| 1 | 1759 | 48.9 | +7.1 | +31.7 | 5 | 1846 | 29.0 | −12.8 | −129.6 |
| 1 | 1760 | 39.0 | −2.8 | +28.9 | 5 | 1847 | 45.2 | +3.4 | −126.2 |
| 1 | 1761 | 32.8 | −9.0 | +19.9 | 5 | 1848 | 41.2 | −0.6 | −126.8 |
| 1 | 1762 | 24.5 | −17.3 | +2.6 | 5 | 1849 | 40.4 | −1.4 | −128.2 |
| 1 | 1763 | 40.5 | −1.3 | +1.3 | 5 | 1850 | 54.8 | +13.0 | −115.2 |
| 1 | 1764 | 36.8 | −5.0 | −3.7 | 5 | 1851 | 41.6 | −0.2 | −115.4 |
| 1 | 1765 | 32.8 | −9.0 | −12.7 | 5 | 1852 | 41.8 | ±0.0 | −115.4 |
| 1 | 1766 | 37.7 | −4.1 | −16.8 | 6 | 1853 | 48.4 | +6.6 | −108.8 |
| 1 | 1767 | 42.4 | +0.6 | −16.2 | 6 | 1854 | 42.3 | +0.5 | −108.3 |
| 1 | 1768 | 36.8 | −5.0 | −21.2 | 6 | 1855 | 42.1 | +0.3 | −108.0 |
| 1 | 1769 | 31.8 | −10.0 | −31.2 | 7 | 1856 | 47.2 | +5.4 | −102.6 |
| 1 | 1770 | 41.3 | −0.5 | −31.7 | 8 | 1857 | 51.6 | +9.8 | −92.8 |
| 1 | 1771 | 45.3 | +3.5 | −28.2 | 8 | 1858 | 41.6 | −0.2 | −93.0 |
| 1 | 1772 | 49.0 | +7.2 | −21.0 | 8 | 1859 | 50.2 | +8.4 | −84.6 |
| 1 | 1773 | 32.6 | −9.2 | −30.2 | 7 | 1860 | 46.1 | +4.3 | −80.3 |
| 1 | 1774 | 37.4 | −4.4 | −34.6 | 8 | 1861 | 42.3 | +0.5 | −79.8 |
| ..... | 1775 | *41.3* | *−0.5* | *−35.1* | 7 | 1862 | 47.5 | +5.7 | −74.1 |
| ..... | 1776 | *42.4* | *+0.6* | *−34.5* | 8 | 1863 | 54.4 | +12.6 | −61.5 |
| 1 | 1777 | 35.5 | −6.3 | −40.8 | 8 | 1864 | 38.7 | −3.1 | −64.6 |
| 1 | 1778 | 37.1 | −4.7 | −45.5 | 10 | 1865 | 38.9 | −2.9 | −67.5 |
| ..... | 1779 | *43.0* | *+1.2* | *−44.3* | 9 | 1866 | 42.2 | +0.4 | −67.1 |
| ..... | 1780 | *40.8* | *−1.0* | *−45.3* | 9 | 1867 | 46.7 | +4.9 | −62.2 |
| ..... | 1781 | *36.5* | *−5.3* | *−50.6* | 10 | 1868 | 46.1 | +4.3 | −57.9 |
| 1 | 1782 | 40.8 | −1.0 | −51.6 | 10 | 1869 | 47.9 | +6.1 | −51.8 |
| 1 | 1783 | 49.7 | +7.9 | −43.7 | 8 | 1870 | 44.3 | +2.5 | −49.3 |
| 1 | 1784 | 60.3 | +18.5 | −25.2 | 8 | 1871 | 39.8 | −2.0 | −51.3 |
| 1 | 1785 | 62.5 | +20.7 | −4.5 | 8 | 1872 | 48.9 | +7.1 | −44.2 |
| 1 | 1786 | 41.5 | −0.3 | −4.8 | 10 | 1873 | 45.4 | +3.6 | −40.6 |
| ..... | 1787 | *36.8* | *−5.0* | *−9.8* | 11 | 1874 | 38.7 | −3.1 | −43.7 |
| ..... | 1788 | *31.8* | *−10.0* | *−19.8* | 11 | 1875 | 47.4 | +5.6 | −38.1 |
| ..... | 1789 | *40.3* | *−1.5* | *−21.3* | 15 | 1876 | 45.9 | +4.1 | −34.0 |
| ..... | 1790 | *39.7* | *−2.1* | *−23.4* | 14 | 1877 | 43.1 | +1.3 | −32.7 |
| ..... | 1791 | *44.2* | *+2.4* | *−21.0* | 17 | 1878 | 54.2 | +12.4 | −20.3 |
| 2 | 1792 | 32.2 | −9.6 | −30.6 | 17 | 1879 | 38.4 | −3.4 | −23.7 |
| 2 | 1793 | 35.4 | −6.4 | −37.0 | 18 | 1880 | 34.1 | −7.7 | −31.4 |
| 2 | 1794 | 33.0 | −8.8 | −45.8 | 17 | 1881 | 42.6 | +0.8 | −30.6 |
| 2 | 1795 | 47.0 | +5.2 | −40.6 | 17 | 1882 | 37.9 | −3.9 | −34.5 |
| 2 | 1796 | 30.1 | −11.7 | −52.3 | 17 | 1883 | 32.7 | −9.1 | −43.6 |
| 2 | 1797 | 39.4 | −2.4 | −54.7 | 16 | 1884 | 46.0 | +4.2 | −39.4 |
| 3 | 1798 | 40.8 | −1.0 | −55.7 | 18 | 1885 | 44.8 | +3.0 | −36.4 |
| 2 | 1799 | 35.4 | −6.4 | −62.1 | 21 | 1886 | 46.4 | +4.6 | −31.8 |
| 3 | 1800 | 45.2 | +3.4 | −58.7 | 20 | 1887 | 45.5 | +3.7 | −28.1 |
| 2 | 1801 | 39.7 | −2.1 | −60.8 | 22 | 1888 | 57.1 | +15.3 | −12.8 |
| 2 | 1802 | 38.4 | −3.4 | −64.2 | 23 | 1889 | 50.9 | +9.1 | −3.7 |
| 2 | 1803 | 43.3 | +1.5 | −62.7 | 28 | 1890 | 49.7 | +7.9 | +4.2 |
| 1 | 1804 | 41.0 | −0.8 | −63.5 | 29 | 1891 | 45.1 | +3.3 | +7.5 |
| ..... | 1805 | *35.5* | *−6.3* | *−69.8* | 28 | 1892 | 38.7 | −3.1 | +4.4 |
| ..... | 1806 | *48.9* | *+7.1* | *−62.7* | 29 | 1893 | 43.6 | +1.8 | +6.2 |
| ..... | 1807 | *46.1* | *+4.3* | *−58.4* | 30 | 1894 | 35.4 | −6.4 | −0.2 |
| ..... | 1808 | *31.8* | *−10.0* | *−68.4* | 30 | 1895 | 45.6 | +3.8 | +3.6 |
| ..... | 1809 | *37.7* | *−4.1* | *−72.5* | 30 | 1896 | 40.4 | −1.4 | +2.2 |
| ..... | 1810 | *40.3* | *−1.5* | *−74.0* | 29 | 1897 | 43.4 | +1.6 | +3.8 |
| ..... | 1811 | *41.8* | *±0.0* | *−74.0* | 27 | 1898 | 54.5 | +12.7 | +16.5 |
| ..... | 1812 | *34.1* | *−7.7* | *−81.7* | 28 | 1899 | 38.4 | −3.4 | +13.1 |
| ..... | 1813 | *48.9* | *+7.1* | *−74.6* | 30 | 1900 | 46.9 | +5.1 | +18.2 |
| ..... | 1814 | *48.9* | *+7.1* | *−67.5* | 30 | 1901 | 52.3 | +10.5 | +28.7 |
| ..... | 1815 | *40.8* | *−1.0* | *−68.5* | 30 | 1902 | 42.8 | +1.0 | +29.7 |
| ..... | 1816 | *27.2* | *−14.6* | *−83.1* | 32 | 1903 | 43.4 | +1.6 | +31.3 |
| ..... | 1817 | *41.5* | *−0.3* | *−83.4* | 32 | 1904 | 42.3 | +0.5 | +31.8 |
| 1 | 1818 | 43.0 | +1.2 | −82.2 | 30 | 1905 | 37.4 | −4.4 | +27.4 |
| 1 | 1819 | 35.5 | −6.3 | −88.5 | 34 | 1906 | 41.9 | +0.1 | +27.5 |
| 1 | 1820 | 44.2 | +2.4 | −86.1 | 32 | 1907 | 41.3 | −0.5 | +27.0 |
| 1 | 1821 | 36.9 | −4.9 | −91.0 | 34 | 1908 | 33.3 | −8.5 | +18.5 |
| 1 | 1822 | 27.2 | −14.6 | −105.6 | 32 | 1909 | 39.9 | −1.9 | +16.6 |
| 1 | 1823 | 47.3 | +5.5 | −100.1 | 34 | 1910 | 31.7 | −10.1 | +6.5 |
| 1 | 1824 | 36.0 | −5.8 | −105.9 | 33 | 1911 | 38.6 | −3.2 | +3.3 |
| 2 | 1825 | 36.7 | −5.1 | −111.0 | 33 | 1912 | 38.3 | −3.5 | −0.2 |
| 3 | 1826 | 37.0 | −4.8 | −115.8 | 33 | 1913 | 40.5 | −1.3 | −1.5 |
| 3 | 1827 | 52.8 | +11.0 | −104.8 | 12 | 1914 | 35.5 | −6.3 | −7.8 |
| 3 | 1828 | 37.3 | −4.5 | −109.3 | 12 | 1915 | 42.5 | +0.7 | −7.1 |
| 3 | 1829 | 42.0 | +0.2 | −109.1 | 11 | 1916 | 40.3 | −1.5 | −8.6 |
| 3 | 1830 | 44.7 | +2.9 | −106.2 | 11 | 1917 | 40.1 | −1.7 | −10.3 |
| 3 | 1831 | 49.7 | +7.9 | −98.3 | 11 | 1918 | 39.3 | −2.5 | −12.8 |
| 3 | 1832 | 48.9 | +7.1 | −91.2 | 11 | 1919 | 45.8 | +4.0 | −8.8 |
| 3 | 1833 | 41.8 | ±0.0 | −91.2 | 11 | 1920 | 49.9 | +8.1 | −0.7 |
| 3 | 1834 | 36.1 | −5.7 | −96.9 | 11 | 1921 | 43.6 | +1.8 | +1.1 |
| 3 | 1835 | 36.5 | −5.3 | −102.2 | 11 | 1922 | 46.8 | +5.0 | +6.1 |
| 3 | 1836 | 37.2 | −4.6 | −106.8 | | | | | |

TABLE 3.—*Annual precipitation over southern New England as shown at from 1 to 10 stations—Base, 42.60.* (*Inches.*)

| Year. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1750 | 42.2 | 53.1 | 38.0 | 52.0 | 46.5 | 38.5 | 35.5 | 41.3 | 53.7 | 48.9 |
| 1760 | 39.0 | 32.8 | 24.5 | 40.5 | 36.8 | 32.8 | 37.7 | 42.4 | 36.8 | 31.8 |
| 1770 | 41.3 | 45.3 | 49.0 | 32.6 | 37.4 | *41.3* | *42.4* | 35.5 | 37.1 | *43.0* |
| 1780 | *40.8* | *36.5* | 40.8 | 49.7 | 60.3 | 62.5 | 41.5 | *36.8* | *31.8* | *40.3* |
| 1790 | 39.7 | *44.2* | 32.2 | 35.4 | 33.0 | 47.0 | 30.1 | 39.4 | 40.8 | 35.4 |
| 1800 | 45.2 | 39.7 | 38.4 | 43.3 | 41.0 | 35.8 | 38.6 | 45.3 | 49.4 | 44.6 |
| 1810 | 39.4 | 47.6 | 44.2 | 53.4 | 49.6 | 45.7 | 41.1 | 43.4 | 40.6 | 36.3 |
| 1820 | 43.9 | 42.4 | 35.6 | 53.6 | 41.7 | 36.7 | 44.2 | 52.7 | 40.5 | 45.8 |
| 1830 | 47.1 | 48.6 | 45.3 | 39.6 | 37.6 | 36.3 | 39.9 | 35.3 | 38.7 | 39.3 |
| 1840 | 42.8 | 44.3 | 41.4 | 46.3 | 37.0 | 41.5 | 33.6 | 45.8 | 40.4 | 37.5 |
| 1850 | 52.7 | 43.6 | 43.3 | 51.1 | 46.7 | 45.0 | 43.2 | 48.1 | 40.9 | 49.9 |
| 1860 | 41.0 | 43.6 | 46.5 | 52.0 | 37.5 | 44.2 | 44.2 | 48.7 | 49.6 | 50.4 |
| 1870 | 45.1 | 47.9 | 45.5 | 45.6 | 43.2 | 44.5 | 46.1 | 44.3 | 52.6 | 42.7 |
| 1880 | 38.2 | 44.3 | 41.8 | 37.2 | 46.3 | 41.7 | 45.4 | 48.0 | 47.7 | 50.9 |
| 1890 | 51.0 | 46.6 | 37.9 | 45.9 | 38.1 | 41.6 | 40.9 | 49.7 | 53.4 | 40.7 |
| 1900 | 45.4 | 50.3 | 45.6 | 44.5 | 42.0 | 38.3 | 43.2 | 43.3 | 37.8 | 39.0 |
| 1910 | 35.4 | 39.7 | 39.5 | 40.2 | 35.3 | 45.2 | 38.9 | 37.7 | 36.0 | 43.4 |
| 1920 | 47.9 | 37.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

Values in italics are interpolated by rule of conformity as explained in text.
Stations (Cambridge, Charlestown or Boston): New Haven after 1804; New Bedford, 1814; New York City, Albany, and Lowell, 1826; Providence, 1832; Amherst, 1835; Worcester, 1841; and Hartford, 1849. Record from all stations nearly complete after 1849.

The writer is strongly of the conviction that the seeming inconsistencies in those portions of Figures 1 and 2 prior to 1849 are best explained from the necessity of uniting the Boston record prior to 1804 to the New Haven and other records beginning at that date without making any allowance for the fact that, as previously shown, the rainfall at New Haven and New Bedford was about 3.8 inches per year greater than at Boston during that period. In other words, the data in Figure 2 are distinctly less homogeneous than are those in Figure 1, and the feature at B′ is due to discontinuity of record rather than climatic change.

A long record of rainfall at Padua,[2] Italy, is given in Table 4 and shown by the method of accumulated sums in Figure 3. In the article cited the data end with the year 1900 and are brought down to date from sources in the library.

Lack of space prevents including many other cases nearly all of which show features like those here discussed. However, the secular trends and the epochs of change appear to be quite local features, and a much more extensive study of data is required before any generalizations are possible.

The method of accumulated sums promises to be invaluable for the purpose of investigating the nature of insidious errors affecting records, especially of rainfall, when data are available which permit of the accurate comparison of two or more records which should be more or less alike.

From the studies thus far conducted two types of conditions appear to prevail, namely:

*Type I. Changeable climate, as exemplified by the illustrations cited above and which appear to afford the most numerous cases.*—In Class I the accumulated sums of departures from base acquire very large positive or negative values separated by wide intervals of time. Steady secular trends fairly well represented by long straight lines, prevail between well-defined epochs at which important changes occur in such secular trends.

[2] J. Hann. Die Schwankungen der Niederslagsmengen in grösseren Zeiträume Sitzungsberichte Kais. Acad. Wiss. 111. 1902. P. 67.

In some cases, as in the Boston and New England records, the values of $y$ with unimportant exceptions are negative for a hundred years or more. In the case of over 90 years rainfall record for Cincinnati, as also for the whole State of Ohio, the values of $y$ are large and continuously *positive* except at the extreme beginning and end of the record.

It is largely a matter of accident or the choice of a base number and the particular time a record of Type I begins whether the values of $y$ will run mostly positive or mostly negative. The Padua record, Table 4, figure 3, shows nearly all positive values, because the base number is a little smaller than the true average. If a base of 34 had been used, the record would have run negative from the start and later become positive, then probably negative at the end. If the record had begun in 1810 and the actual average used for the base number the values of $y$ would all have been negative, with no important exceptions. None of these arbitrary changes in methods of calculation of $y$ would, however, materially alter the epochal features A, B, C, etc.

*Type II. Stable climates.*—In the case of climatic records of this type, the values of the accumulated sums turn out more or less according to expectations or theory; that is, the values of $y$ never become very large, the sum passes through zero, that is, changes sign frequently; epochal features like A, B, C, etc., are absent, and the base line itself is the best representation of secular trend that can be chosen. Such a climate is strictly a normal climate all the time and devoid of any of the long-time changes which are conspicuous in Type I.

The rainfall record covering a period of 105 years at Marietta, Ohio, Table 5, figure 4, is one of the best examples of the stable type of climate thus far examined.

In order to show the power of analysis of the method of accumulated sums, a final illustration will be given:

TABLE 4.—*Annual precipitation at Padua, Italy, 1725 to 1921 (centimeters).*

| Year. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1720 | | | | | | 759 | 629 | 1,162 | 1,348 | 924 |
| 1730 | 871 | 866 | 814 | 879 | 961 | 775 | 792 | 606 | 713 | 645 |
| 1740 | 570 | 614 | 991 | 717 | 906 | 963 | 1,056 | 649 | 1,052 | 918 |
| 1750 | 821 | 1,073 | 961 | 1,000 | 705 | 1,101 | 994 | 795 | 1,111 | 919 |
| 1760 | 887 | 1,126 | 572 | 947 | 1,069 | 982 | 841 | 902 | 763 | 1,061 |
| 1770 | 1,372 | 1,062 | 1,563 | 1,129 | 760 | 916 | 943 | 1,184 | 868 | 826 |
| 1780 | 812 | 940 | 821 | 825 | 791 | 918 | 1,037 | 852 | 824 | 748 |
| 1790 | 597 | 679 | 670 | 947 | 1,041 | 897 | 845 | 722 | 868 | 1,121 |
| 1800 | 1,003 | 903 | 1,110 | 1,142 | 1,130 | 893 | 991 | 1,184 | 738 | 1,089 |
| 1810 | 973 | 661 | 1,029 | 729 | 839 | 718 | 553 | 575 | 827 | 863 |
| 1820 | 515 | 671 | 480 | 779 | 763 | 660 | 990 | 841 | 617 | 800 |
| 1830 | 597 | 790 | 673 | 949 | 501 | 912 | 958 | 952 | 821 | 809 |
| 1840 | 614 | 713 | 699 | 752 | 933 | 1,265 | 957 | 748 | 843 | 680 |
| 1850 | 948 | 1,030 | 747 | 1,034 | 718 | 1,139 | 1,015 | 653 | 806 | 809 |
| 1860 | 884 | 533 | 1,128 | 789 | 790 | 619 | 731 | 862 | 913 | 1,083 |
| 1870 | 698 | 712 | 1,088 | 919 | 720 | 821 | 1,032 | 971 | 886 | 852 |
| 1880 | 747 | 684 | 813 | 701 | 768 | 892 | 835 | 908 | 648 | 963 |
| 1890 | 689 | 671 | 991 | 580 | 563 | 956 | 1,186 | 785 | 983 | 589 |
| 1900 | 993 | 1,006 | 851 | 800 | 794 | 1,206 | 819 | 716 | 572 | 924 |
| 1910 | 1,073 | 907 | 762 | 860 | 773 | 944 | 1,132 | 742 | 971 | 876 |
| 1920 | 910 | 430 | | | | | | | | |

TABLE 5.—*Annual precipitation at Marietta, Ohio, 1818 to 1922—Base, 42.20. (Inches.)*

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1810 | | | | | | | | | 50.9 | 36.3 |
| 1820 | 39.1 | 43.3 | 43.4 | *42.2* | *42.2* | *42.2* | 41.6 | 41.5 | 49.5 | 39.5 |
| 1830 | 37.3 | 53.5 | 48.3 | 40.4 | 34.7 | 42.5 | 36.8 | 43.9 | 35.5 | 33.3 |
| 1840 | 39.1 | 42.8 | 42.1 | 41.8 | 36.6 | 33.9 | 46.3 | 52.3 | 43.2 | 42.9 |
| 1850 | 52.4 | 34.9 | 46.5 | 37.0 | 38.8 | 45.8 | 32.5 | 40.6 | 61.8 | 48.6 |
| 1860 | 38.9 | 46.4 | 42.7 | 37.1 | 40.9 | 48.8 | 47.3 | 46.7 | 50.1 | 42.9 |
| 1870 | 40.2 | 29.0 | *42.2* | 48.0 | 39.6 | 46.0 | 48.2 | 34.4 | 37.5 | 30.5 |
| 1880 | 46.4 | 36.8 | 60.0 | 46.8 | 38.5 | 41.7 | 42.1 | 37.2 | 55.4 | 41.0 |
| 1890 | 61.0 | 40.8 | 34.8 | 40.5 | 30.5 | 26.6 | 43.2 | 41.4 | 48.1 | 43.7 |
| 1900 | 38.4 | 37.6 | 44.1 | 41.9 | 26.0 | 46.4 | 40.6 | 53.1 | 32.5 | 45.4 |
| 1910 | 31.2 | 45.9 | 35.1 | 50.7 | 35.4 | 44.0 | 43.2 | 45.5 | 45.6 | 46.8 |
| 1920 | 40.8 | 51.3 | 46.4 | | | | | | | |

Some will perhaps hesitate to believe that the precipitation in the vicinity of Boston, for example, was really less per annum for 90 or 100 years prior to 1849 but was only seemingly so because the untrained observers in those days did not measure all the snowfall, for example. This is a very plausible view, but it does not stand critical analysis, or better, we may say the cause, on the whole, is quantitatively inadequate and inconsistent with the facts. Anyone who goes into the details and history of early meteorological records must soon find a good deal of confidence in their general accuracy and a deserved respect for the motives, persistence, and intelligence which guided the enthusiastic observers of former years. Moreover, it will probably turn out that plenty of early records show excesses as compared with present-day values, so that the tentative impeachment of early records on the grounds of faulty methods of measuring snow must generally fail.

To test this question of winter and annual precipitation, we have reasoned and proceeded as follows:

(1) Most of the snowfall over southern New England occurs during the months of November, December, January, February, and March.

(2) In the absence of any evidence and demonstrations to the contrary, we are quite justified in assuming (*a*) that the ratio of the winter precipitation to that for the year at a given station tends to be a constant with the lapse of time; (*b*) that over the limited region now considered the winter ratio will be sensibly the same for all stations.

(3) If the snowfall is incompletely measured at any period of the record the ratio will necessarily be smaller and appear in the record, especially if analyzed by the method of accumulated sums. The result of such a study is shown in Figure 5 for the group of 10 stations in southern New England covering the period 1751 to 1921.

Four gaps in this record of 2, 3, 6, and 2 years have been filled by estimations based on the rule of conformity of missing record to actual records for dates, before and after the gaps. As this rule of conformity may not as yet have the indorsement and approval of meteorologists in general, it seems proper to give here the basis upon which the present application seems fully justified.

| | |
|---|---|
| Average ratio 25 years unbroken record at Cambridge, 1751–1775 | 0.389 |
| Average 4 winters at Andover, 1783–1786 | .416 |
| Average 10 winters at Charlestown, 1793–1802 | .383 |
| Average 10 winters at New Haven, 1805–1814 | .417 |
| General average | .401 |
| General average for 171 years | .404 |

The first three records are for stations quite close to Boston, and there is a gap of two years from 1802 to 1804 when the record began far to the southwest. A critic of these values may regret that the individual values differ as much as they do, but the general agreement and the close identity of the mean of the four values with the mean for the whole period of 171 years can not be lightly disregarded, and the writer feels strongly inclined to regard this rule of conformity as a safe guide in filling such small gaps in the record as are involved in this example. As in the earlier case, we have resorted to the scheme of drawing numbers from a cup to secure individual values.

What is to be the interpretation of Figure 5, which was designed to show whether early measurements of snowfall and winter precipitation in general were as accurate and dependable as those of the present day?

The diagram presents one very striking feature, namely, the point *A* marking a decided epoch at 1875 when the ratio of winter precipitation changed from 39.5 per cent to 43.4 per cent (a still greater change might be claimed).

During the 125 years prior to 1875 a number of marked fluctuations in the average value of the ratio prevailed, but there is no evidence of conspicuous features. Making full allowance for the uncertainty in the interpolated missing values, it is obvious that the general results are not materially affected by these interpolated values. A few fairly well defined secular trends, such as shown by the dotted lines O, C, D, A, Figure 5, might be claimed, but it seems quite unlikely these are real. They are probably due to inherent uncertainties in the records, including the rather serious discontinuity at 1804 in passing from the early records at Boston to the series beginning at New Haven and New Bedford in 1804 and 1814. If they are real, we must say:

| | Per cent. |
|---|---|
| Average winter ratio for 30 years, 1750 to 1780 | 38.9 |
| Ditto for about 50 years, 1783 to 1832 | 40.6 |
| Ditto for nearly 45 years, 1830 to 1875 | 39.1 |

It is probable that these different winter ratios represent different degrees of accuracy in the measurement of snowfall, or possibly some slight changes may have prevailed in the seasonal distribution during the different periods. On the whole, however, the quantitative magnitudes of the differences is quite too small to be significant, and the safest conclusion that can be drawn from the whole record is that during the 125 years prior to 1875 the ratio of winter precipitation to that of the whole year (beginning with April 1, not January 1) averaged 39.5 per cent, whereas following 1875 the winter ratio averaged over 43 per cent. The epoch 1875 coincides very closely with the beginning of observation by the Weather Bureau, which it might be supposed marked the beginning of the best possible measurement of snowfall, thus explaining the higher ratio of winter precipitation. This reasoning, however, can not be relied upon, because (1) the change in ratio was sudden, definite, and continuous; (2) the history of the Weather Bureau methods of snow measurement does not allow the belief that the records from other good observing stations in those early years could have been sufficiently inaccurate, compared with Weather Bureau records, to explain the considerable and abrupt change. Finally, (3) we are dealing with a composite record of 10 stations, only 3 of which in 1875 were Weather Bureau stations. The percentage influence of those stations is too small to affect the average of all the stations sufficiently to explain the result observed. The literature of the early observations shows that the importance and difficulties of correctly measuring snowfall was fully appreciated, and while the exact methods followed are not known, the observations must be accepted, in this case at least, as fairly homogeneous, and we are compelled to conclude that about 1875 some climatic changes occurred over the region embraced which caused the ratio of winter precipitation to change from about 39 to 43 per cent. While the smaller value of the ratio during the early years of the record is no doubt due in part to the incomplete measurement of winter precipitation, yet this influence alone fails to furnish a satisfactory explanation of all the record, and we must recognize that some significant climatic change has also been an important influence in fixing the annual distribution of precipitation.

It is not possible in this short article to give the results of similar studies of records for Washington, the State of Ohio, eastern Kansas, portions of Louisiana and elsewhere, and which include conditions of temperature and pressure as well as rainfall, all of which support the views advanced herein.

## GENERAL CONCLUSIONS.

*Normals.*—The practical and useful significance of the concept *Normal* in weather and climatology is simply that of a convenient base number approximately equal to the average of observations over a period of, say, 50 years more or less. *A true or absolute normal* is, of course, the average of observations covering a period of several hundred years, but such a value will differ only slightly, in general, from an ordinary average, and it possesses no magic significance.

*Accumulated sums of departures from base.*—Tables and diagrams of the accumulated sums of departures from base and from a given epoch are most useful in exhibiting secular trends and epochal features in the data represented and show two distinct types, viz., (I) the changeable type, marked by secular trends away from the adopted normal which prevail steadily for many years and quite abruptly give place to definite trends of an opposite or different value, which in turn gives place to still other persistent trends.

Type II is a stable type in which departures of the same kind prevail for only short periods. In this type the normal, or base number itself, is the best representation of secular trend that can be chosen. It is quite probable that both types may be found combined in some way when records of several hundred years become available for analysis, so that in the end what now seems to be two types based on relatively short records will ultimately appear as different features of all very long records.

*Climatic changes.*—While there is no evidence indicating any permanent changes in climate, these studies demonstrate that more or less definite epochs occur from time to time when the climatic conditions of a more or less limited region suffer a material change in the value of the running average of conditions. These periods may prevail from 50 to 100 years or more, after which some other marked change occurs. Unquestionably, such features of records call for much further study and investigation. Shorter periods also are found and admit of more careful analysis because of their greater number and frequency.

*Future studies facilitated.*—The accumulated sums of departures from base have such a broad value of utility in all statistical studies that agencies responsible for the collection, compilation, and publication of meteorological and other data may well be justified in the systematic computation of this additional fundamental datum for all principal elements. The practice of printing *departures from normal* is already a very common one, and only slight additional work is required to include the *A. S.* in such data. This can not fail to furnish the student of climatic changes and weather sequences extremely valuable material.

*Caution.*—Two points in connection with this paper must be kept plainly in mind: (1) Straight lines are of course crude first approximations to secular trends; (2) the elimination of secular trends is necessary in the pursuit of many investigations, such as the evaluation of periodic and other recurrent features, solar and terrestrial correlations and the like. The method of accumulated sums seems superior to any other for accurately evaluating secular trends, and the use of ordinary averages, or of so-called normals based upon even 200 years' observations as secular trends is misleading unless it is shown the data used belongs to the stable class designated Type II.

# AN IMPROVED METHOD OF COMPUTING METEOROLOGICAL NORMALS.[1]

By H. W. CLOUGH, Meteorologist.

[Weather Bureau, Washington, D. C., Sept. 27, 1923.]

*The meteorological normal.*—The average, or arithmetic mean, has always been regarded as the most probable value of a quantity measured several times with equal care. Meteorologists have universally regarded the average of a long series of observations, as yearly amounts of rainfall, yearly mean temperatures, etc., as the best available approximation to the true normal. The instability of the average of a short series is well known. Such averages of successively greater and greater periods of time, as the 10, 20, 30, etc., year mean, tend to fluctuate above and below the true normal with a steadily diminishing range of variation until finally with a long record of, say, 75 to 100 years, they become sensibly constant, coinciding with the true normal.

The underlying assumption is that the trend of the data is a linear one and departs little from horizontality. While it may be true that long secular variations in the rate of rainfall may occur, we are not in the present state of our knowledge justified in regarding the normal otherwise than as an average that tends to become constant as the length of record increases. As a matter of fact, the majority of records at stations with a continental exposure, with the 30 to 40 year Brückner cycle eliminated, show only slight deviations from a linear horizontal trend. Marked deviations from such a trend imply either nonhomogeneity of record or local peculiarities of exposure, such as a location in proximity to mountain ranges or on the borders of continents.

*Newcomb's least square method of deriving the mean period of the solar spots.*—In his paper on the period of the solar spots [2] Newcomb employed a least-square solution of the data to determine the true normal period and the normal epochs. He showed that the arithmetic average of varying intervals could not be the true normal period. For example, the 27 intervals between the maxima of 1615.5 and 1917.6 yield an average of 11.19 years. But the 25 intervals, 1626.0 to 1906.4 yield an independent determination of 11.22 years, of nearly equal weight, and the 23 intervals, 1639.5 to 1894.1, another independent value of 11.07 years. The series thus yields a number of independent determinations with continually decreasing weights, the weights varying with the square of the number of intervals, and the true normal is the weighted mean of these varying values. He, however, employed the ordinary least-square method, forming an equation of condition from each epoch of maxima and minima in the form of $y=a+bx$, in which $y$ is the epoch or date of occurrence of maximum, $x$ the number of the epoch, beginning with 1615.5, $b$ the mean period, and $a$ the departure of the observed epoch from the normal epoch. The solution of the 27 equations thus formed gives the normal epoch and the normal period, which he thus determined to be 11.13 years.

*The method applied to the derivation of meteorological normals.*—It occurred to the writer during a recent reading of Newcomb's paper that the method could be used to compute meteorological normals more accurately than could be done by the simple method of averaging. Just how this was to be accomplished required some consideration of the varying conditions involved. The normal annual rainfall is the mean rate at which the total rainfall increases with yearly increments of time. Representing the relation in the form of an equation, $y=bx$, the independent variable, $x$, is time, 1, 2, 3, etc., years, the dependent variable, $y$, is rainfall while $b$ is the normal annual rainfall. In the case of the sunspots, $x$ is the number of the successive maxima and $y$ the corresponding epoch or the date of occurrence. The successive intervals between maxima correspond to yearly amounts of rainfall. It was clear then that it would be necessary to compute accumulated amounts of rainfall to correspond with the epochs, representing accumulated amounts of time, which Newcomb had already at his disposal. It was, therefore, not difficult for him to devise a method for deriving a more accurate normal than the arithmetic average. Meteorologists, however, have been accustomed to the use of partial summations only, of rainfall, for uniform intervals like days, months and the year. They have plotted the individual yearly amounts and joined the tops of the ordinates, forming a line which has no mathematical significance, since it does not represent a continuous function of time. They have employed accumulated daily departures of rainfall and temperature for the purpose of showing the average departure since the first of the year or month, but have rarely or never computed accumulated amounts of rainfall for successive years, which would have afforded a clue to the new method. It is not surprising, therefore, that it has so far evaded discovery.

A strict analogue with the problem of determining the mean interval between sunspot maxima would be that of deriving the annual period of rainfall and the average date of maximum at a station with a pronounced annual variation, as, for example, San Francisco. By employing the monthly amounts and smoothing them, as Wolfer did with the monthly sunspot values, there would result a series of epochs of maxima, averaging very nearly a year apart, and the true interval could be derived by precisely the same method that Newcomb employed. The evaluation of the constants in the equation $y=a+bx$ would yield both $a$, the normal epoch of the maximum, and $b$, the mean interval, one year.

The process may be illustrated graphically by plotting the data with the epochs as ordinates and the numbers of the epochs as abscissas. The line of best fit to the data thus plotted is the equivalent of the equation derived by the least square solution. The constant $a$ is the distance from the origin at which the line intersects the $y$-axis and $b$ is the slope of the line. It is evident that the mean interval between maxima obtained by averaging is merely the slope of the line joining the origin and the last dot, while the true interval is the slope of the line of best fit to all the data. This line does not necessarily pass through the origin.

On the other hand, the line joining the successive summations of annual rainfall, when plotted, starts from the origin, the line representing the data must pass through the origin, and the equation of the line is in the form of $y=bx$. It is assumed that $y=0$ when $x=0$. There is only one constant involved, viz., the slope of the line, corresponding to the mean yearly rate of rainfall, while with the rainfall data in the other form, two are involved, the mean epoch and the mean interval. If the meteorological data be perfectly homogeneous and the dispersion of the data be not too great and the length of record sufficiently long, the line of best fit to the data, if computed by the equation $y=a+bx$, will pass close to the origin.

[1] Read at meeting American Meteorological Soc., Washington, D. C., April 16, 1923.
[2] Astroph. Jour, 1901. 13:1

When accumulated departures from an average instead of the accumulated actual amounts are plotted, the line joining the plotted data does not pass through the origin, the line of best fit to the data will likewise not pass through the origin and it will be necessary to represent it by the equation $y=a+bx$.

*Evaluation of the constants a and b.*—As previously stated, the San Francisco rainfall problem involves the equation $y=a+bx$, since we require both the mean epoch and the mean interval. In the computation of meteorological normals only one constant is required, the slope of the line, and the evaluation of this constant $b$, in the equation $y=bx$, is a much simpler process than the evaluation of $b$ in $y=a+bx$. Since, however, the latter equation is useful in certain cases, an account of the processes necessary for its solution will be given.

TABLE 1.—*Data and computations involved in the evaluation of the constants in equations, $y=a+bx$ and $y=bx$.*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number.. | $n$ | $x$ | $y$ | $\Sigma x$ | $\Sigma y$ | $x^2$ | $\Sigma x^2$ | $xy$ | $\Sigma xy$ | Arith. average $\frac{y}{x}$ | $\frac{\Sigma xy}{\Sigma x^2}$ | $\frac{\Sigma y}{\Sigma x}$ |
| 2..... | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | ..... | ..... | ..... |
| 11..... | 3 | 2 | 13 | 3 | 15 | 4 | 5 | 26 | 28 | 6.50 | ..... | ..... |
| 15..... | 4 | 3 | 28 | 6 | 43 | 9 | 14 | 84 | 112 | 9.33 | ..... | ..... |
| 4..... | 5 | 4 | 32 | 10 | 75 | 16 | 30 | 128 | 240 | 8.00 | 8.00 | 7.50 |
| 6..... | 6 | 5 | 38 | 15 | 113 | 25 | 55 | 190 | 430 | 7.60 | 7.82 | 7.53 |
| 11..... | 7 | 6 | 49 | 21 | 162 | 36 | 91 | 294 | 724 | 8.17 | 7.96 | 7.71 |
| 12..... | 8 | 7 | 61 | 28 | 223 | 49 | 140 | 427 | 1,151 | 8.71 | 8.22 | 7.97 |
| 0..... | 9 | 8 | 61 | 36 | 284 | 64 | 204 | 488 | 1,639 | 7.62 | 8.03 | 7.89 |

Solution of constants $a$ and $b$ in equation $y=a+bx$:

$$b=\frac{9\times1639-36\times284}{9\times204-(36)^2}=8.38 \qquad a=\frac{284-36\times8.38}{9}=-1.96$$

Solution by abridged formula:

$$b=\frac{1639-4\times284}{60}=8.38$$

Table 1 illustrates the method of computation for a series of eight arbitrarily selected numbers. which are given in column 1. $x_1\ x_2\ x_3\ \ldots$ represent the first, second, third, etc., numbers, while $y_1\ y_2\ y_3\ \ldots$ are the accumulated amounts. Since the first value of $y$ is zero, $n$ is always one greater than $x$. The other columns of the table are self-explanatory. The formulas for $a$ and $b$ are

$$b=\frac{n(\Sigma xy)-(\Sigma x)\ (\Sigma y)}{n(\Sigma x^2)-(\Sigma x)^2} \qquad a=\frac{\Sigma y-b\Sigma x}{n}$$

*Special solution when x's are equidistant integers.*—An abridged formula is available when the values of $x$ are equidistant integers, as is the case with the computation of meteorological normals. This formula is

$$b=\frac{\Sigma xy-m\Sigma y}{d}$$

The values of the constants $m$ and $d$ for values of $x$ up to 15 are contained in the following table.

| $x$ | $m$ | $d$ | $x$ | $m$ | $d$ |
|---|---|---|---|---|---|
| 1 | 0.5 | 0.5 | 9 | 4.5 | 82.5 |
| 2 | 1.0 | 2.0 | 10 | 5.0 | 110.0 |
| 3 | 1.5 | 5.0 | 11 | 5.5 | 143.0 |
| 4 | 2.0 | 10.0 | 12 | 6.0 | 182.0 |
| 5 | 2.5 | 17.5 | 13 | 6.5 | 227.5 |
| 6 | 3.0 | 28.0 | 14 | 7.0 | 280.0 |
| 7 | 3.5 | 42.0 | 15 | 7.5 | 340.0 |
| 8 | 4.0 | 60.0 | | | |

*Evaluation of b by the method of weighted means.*—Another method is to take the mean of the actual data, weighted in accordance with the following table for varying values of $n$, the number of terms.

| $n$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 3..... | 3 | 4 | 3 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4..... | 4 | 6 | 6 | 4 | ..... | ..... | ..... | ..... | ..... | ..... |
| 5..... | 5 | 8 | 9 | 8 | 5 | ..... | ..... | ..... | ..... | ..... |
| 6..... | 6 | 10 | 12 | 12 | 10 | 6 | ..... | ..... | ..... | ..... |
| 7..... | 7 | 12 | 15 | 16 | 15 | 12 | 7 | ..... | ..... | ..... |
| 8..... | 8 | 14 | 18 | 20 | 20 | 18 | 14 | 8 | ..... | ..... |
| 9..... | 9 | 16 | 21 | 24 | 25 | 24 | 21 | 16 | 9 | ..... |
| 10..... | 10 | 18 | 24 | 28 | 30 | 30 | 28 | 24 | 18 | 10 |

It will be seen that the middle term of the series is given the greatest weight, and the extreme terms have the least weight. The trend of the line of best fit is thus very largely determined by the middle values, and is only slightly altered by the addition of another term, abnormal though it may be.

*Solution by weighted mean.*

| Number. | Weight. | Product. |
|---|---|---|
| 2 | 4 | 8 |
| 11 | 7 | 77 |
| 15 | 9 | 135 |
| 4 | 10 | 40 |
| 6 | 10 | 60 |
| 11 | 9 | 99 |
| 12 | 7 | 84 |
| 0 | 4 | 0 |
| | 60 | 503 |

$$\frac{503}{60}=8.38$$

*Evaluation of the constant b in the equation $y=bx$.*—As above stated, the equation representing the straight line of best fit to plotted data comprising accumulated amounts of rainfall, temperature, etc., has but one constant, since the line passes through the origin. This value of $b$ is evaluated with much greater facility than that in the equation containing two constants.

There are two methods for computing $b$. One is the zero-sum method, by which the algebraic sum of the residuals of the $y$'s from the line of best fit equals zero. The other is the least square method, by which the sum of the squares of the residuals is a minimum. The formula for the first method is $b=\frac{\Sigma y}{\Sigma x}$. In this case $b$ is the slope of the line drawn from the origin to the mean ordinate or the average of all the $y$'s, calling the first $y$ zero. For the least square method the formula is $b=\frac{\Sigma xy}{\Sigma x^2}$. Values of $b$ computed by these formulas are given in columns 12 and 13 of Table 1.

*Evaluation of b by the method of weighted means.*—Since the arithmetic average is the mean of a series of data of equal weight, it is evident that the methods for obtaining $b$ by these formulas are the equivalent of giving the data unequal weight. These weights are shown in the following table for values of $n$ up to 5, and weights for series of a greater number of terms are readily deducible from the table:

| | $n$ | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| $b=\frac{\Sigma y}{\Sigma x}$ | 2 | 2 | 1 | ..... | ..... | ..... |
| | 3 | 3 | 2 | 1 | ..... | ..... |
| | 4 | 4 | 3 | 2 | 1 | ..... |
| | 5 | 5 | 4 | 3 | 2 | 1 |
| $b=\frac{\Sigma xy}{\Sigma x^2}$ | 2 | 3 | 2 | ..... | ..... | ..... |
| | 3 | 6 | 5 | 3 | ..... | ..... |
| | 4 | 10 | 9 | 7 | 4 | ..... |
| | 5 | 15 | 14 | 12 | 9 | 5 |

*Comparison of the two methods.*—The least square method thus yields somewhat different results from the zero-sum method by giving relatively greater weight to the final values of the series, and to that extent they follow more closely the fluctuations of the arithmetic average. They are less stable than the zero-sum values, but the two results tend to become identical with a sufficiently long record. The greater facility of computation, together with the superior stability of the results by the zero-sum method, make the employment of this method preferable in most cases. If, however, the first few values of a series are markedly above or below the average, the excessive weight given to these values by this method results in faulty final values of $b$. In such cases the first value of $y$ employed should be that at which the arithmetic average begins to be fairly stable, the precise point depending upon the abnormality of the early values. Illustration of this modification of the method will be given below.

*The method a general one for determining the true mean of samples of numbers normally distributed about a mean.*—Table 2 illustrates the method of computing the true mean of a series of numbers composing a sample of numbers whose theoretical mean is rigorously determinate by the conditions under which the numbers were selected. Bowley [3] gives a series of 300 numbers whose average is 25.04, median 25.2, and mode 25.5; but the true mean of a long series of numbers, of which the list is a sample, is 25.00. I have combined these numbers by tens, forming a series of 30 numbers. These numbers, diminished by 20, appear in column 2. It will be seen that the average of the first few numbers is much below the mean and that the values of $b$ by the zero-sum method are persistently low. If, however, the first nine values of $x$ and $y$ are ignored, and the first value of $y$ is that corresponding to $x=10$, or 5.04, there is obtained a fairly stable series of values for $b$ shown in column 7 whose mean deviation from 5.0 is 0.028, as compared with a mean deviation of 0.056 for the arithmetic averages. The fluctuations of $b$ lag somewhat behind those of the averages, which accords with its greater stability.

TABLE 2.—*Values of b by methods (1), (2) and (3) for a series of 30 numbers whose true mean is 5.00.*

| $x$ | Numbers. | Arith. average. | $\frac{\Sigma xy}{\Sigma x^2}$ | $\frac{\Sigma y}{\Sigma x}$ | $y$ | $\frac{\Sigma y}{\Sigma x}$ beginning with $x=10$. |
|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 1 | 3.6 | ..... | ..... | ..... | ..... | ..... |
| 2 | 4.8 | 4.20 | ..... | ..... | 8.4 | ..... |
| 3 | 4.4 | 4.27 | ..... | ..... | 12.8 | ..... |
| 4 | 4.6 | 4.35 | ..... | ..... | 17.4 | ..... |
| 5 | 5.3 | 4.54 | ..... | ..... | 22.2 | ..... |
| 6 | 3.6 | 4.38 | ..... | ..... | 26.3 | ..... |
| 7 | 5.7 | 4.71 | ..... | ..... | 32.0 | ..... |
| 8 | 5.8 | 4.73 | ..... | ..... | 37.8 | ..... |
| 9 | 6.6 | 4.93 | ..... | ..... | 44.4 | ..... |
| 10 | 6.0 | 5.04 | 4.75 | 4.65 | 50.4 | 5.04 |
| 11 | 4.5 | 4.99 | 4.81 | 4.71 | 54.9 | 5.01 |
| 12 | 5.0 | 5.00 | 4.85 | 4.75 | 59.9 | 5.01 |
| 13 | 4.7 | 4.97 | 4.87 | 4.78 | 64.6 | 5.00 |
| 14 | 6.9 | 5.11 | 4.92 | 4.82 | 71.5 | 5.02 |
| 15 | 5.5 | 5.13 | 4.96 | 4.86 | 77.0 | 5.04 |
| 16 | 3.8 | 5.05 | 4.97 | 4.89 | 80.8 | 5.04 |
| 17 | 4.3 | 5.00 | 4.98 | 4.90 | 85.1 | 5.03 |
| 18 | 4.3 | 4.97 | 4.98 | 4.91 | 89.4 | 5.02 |
| 19 | 4.0 | 4.92 | 4.97 | 4.91 | 93.4 | 5.00 |
| 20 | 3.8 | 4.86 | 4.95 | 4.90 | 97.2 | 4.98 |
| 21 | 4.4 | 4.89 | 4.94 | 4.90 | 101.6 | 4.97 |
| 22 | 6.6 | 4.92 | 4.94 | 4.90 | 108.2 | 4.96 |
| 23 | 4.4 | 4.90 | 4.93 | 4.90 | 112.6 | 4.96 |
| 24 | 5.5 | 4.92 | 4.93 | 4.90 | 118.1 | 4.96 |
| 25 | 5.6 | 4.95 | 4.94 | 4.91 | 123.7 | 4.96 |
| 26 | 6.8 | 5.02 | 4.94 | 4.91 | 130.5 | 4.96 |
| 27 | 4.0 | 4.98 | 4.95 | 4.92 | 134.5 | 4.97 |
| 28 | 6.2 | 5.02 | 4.96 | 4.93 | 140.7 | 4.97 |
| 29 | 5.6 | 5.04 | 4.96 | 4.93 | 146.3 | 4.98 |
| 30 | 5.0 | 5.04 | 4.97 | 4.94 | 151.3 | 4.98 |

Example: The value of $b$ in the last column corresponding to $x=15$ is the sum of the $y$'s from 10 to 15, inclusive, or 378.3, divided by the sum of the $x$'s, or 75.

[3] *Elements of statistics*, p. 289.

This example shows that the method is of universal application to determine the true mean of a series of numbers normally distributed about a mean in accordance with the Gaussian law of error. Such series of numbers include all physical measurements, which are subject only to the accidental errors of observation. Statisticians deal largely with samples, whose true mean is a desideratum unattainable by the method of simple averaging.

There may be systematic as well as accidental deviations, but if they are equally distributed about the mean, the method is still applicable. Meteorological data partake of this character, there being persistent deviations above and below the mean, due probably to periodic causes, which result in departures from a purely fortuitous order of sequence.[4] The most important of these effects which require to be eliminated in the computation of yearly normals is that due to the Brückner cycle of about 35 years. The extreme range of the variation due to this cycle may amount to about 25 per cent of the normal.

*The use of lustrum means to facilitate computation.*—In actual practice, the combination of long series of numbers by threes, fives, or tens gives accurate results with much saving of labor. In the last example, averaging by fives gives six numbers, and the following table shows the values of $b$ computed by the several methods.

| Means of five. | (1) Arith. average. | (2) $b=\frac{\Sigma xy}{\Sigma x^2}$ | (3) $b=\frac{\Sigma y}{\Sigma x}$ |
|---|---|---|---|
| 4.54 | ..... | ..... | ..... |
| 5.54 | 5.04 | 4.94 | 4.87 |
| 5.32 | 5.13 | 5.06 | 5.00 |
| 4.04 | 4.86 | 4.96 | 4.95 |
| 5.30 | 4.95 | 4.95 | 4.95 |
| 5.52 | 5.04 | 4.99 | 4.97 |

The Washington mean annual temperatures, by lustrums, yields the following results for the years 1871–1920:

| Lustrum means 50°+ | (1) Average. | (2) $b=\frac{\Sigma xy}{\Sigma x^2}$ | (3) $b=\frac{\Sigma y}{\Sigma x}$ |
|---|---|---|---|
| ° | ° | ° | ° |
| 4.52 | ..... | ..... | ..... |
| 5.30 | 4.91 | 4.83 | 4.78 |
| 4.58 | 4.80 | 4.81 | 4.79 |
| 4.64 | 4.76 | 4.78 | 4.78 |
| 4.74 | 4.76 | 4.77 | 4.77 |
| 5.48 | 4.88 | 4.81 | 4.80 |
| 3.90 | 4.74 | 4.79 | 4.79 |
| 5.04 | 4.78 | 4.78 | 4.78 |
| 5.74 | 4.88 | 4.81 | 4.80 |
| 4.94 | 4.89 | 4.83 | 4.82 |
| ..... | [1] 4.98 | ..... | ..... |

[1] To include 1922.

The average deviation of the values of $b$ from an assumed mean of 4.82 is for the different methods: (1) 0.06, (2) 0.03, (3) 0.024.

The extreme range is: (1) 0.17, (2) 0.06, (3) 0.05.

The Washington annual rainfall, by lustrums, for the years 1871–1920 yields the following results:

| Lustrum means. | (1) | (2) | (3) |
|---|---|---|---|
| 38.1 | ..... | ..... | ..... |
| 46.5 | 42.3 | 41.42 | 40.87 |
| 45.9 | 43.5 | 42.74 | 42.17 |
| 48.2 | 44.7 | 43.77 | 43.17 |
| 39.4 | 43.6 | 43.70 | 43.31 |
| 39.7 | 43.0 | 43.41 | 43.21 |
| 44.7 | 43.2 | 43.34 | 43.21 |
| 41.7 | 43.0 | 43.22 | 43.17 |
| 40.5 | 42.7 | 43.09 | 43.09 |
| 39.3 | 42.4 | 42.91 | 42.96 |

[4] Cf. MO. WEATHER REV., 1921, 49: 128–129. Clough, A statistical comparison of meteorological data with data of random occurrence.

Beginning with the fourth lustrum, the dispersion of the values computed by the three methods is as follows:

| | (1) | (2) | (3) |
|---|---|---|---|
| Mean variablity | 0.45 | 0.14 | 0.08 |
| Extreme range | 2.30 | .86 | .35 |

The rainfall record at New Bedford, Mass., from 1814 to 1908 is the longest in the United States and is regarded as of exceptionally high quality. Table 3 gives the lustrum means and the normals by methods (1), (2), and (3). By the end of the fifth lustrum the averages begin to be fairly stable. Beginning with the values at the end of this lustrum, this following measures of dispersion of the values by the different methods have been computed.

| | (1) | (2) | (3) |
|---|---|---|---|
| Mean deviation from 46.50 | 0.38 | 0.17 | 0.12 |
| Extreme range | 1.10 | .68 | .29 |
| Mean variability | .20 | .08 | .05 |

The fluctuations of the arithmetic averages are thus about four times greater than those of the normals computed by the zero-sum method.

TABLE 3.—*Lustrum means of rainfall at NewBedford and normal values computed by methods (1), (2), and (3). 40 inches + tabular values.*

| Number of lustrum. | Lustrum means. | (1) | (2) | (3) | Number of lustrum. | Lustrum means. | (1) | (2) | (3) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.4 | | | | 11 | 6.1 | 6.1 | 6.35 | 6.36 |
| 2 | 5.7 | 4.0 | 3.60 | 3.50 | 12 | 9.2 | 6.4 | 6.35 | 6.36 |
| 3 | 8.6 | 5.6 | 4.90 | 4.50 | 13 | 7.5 | 6.4 | 6.38 | 6.37 |
| 4 | 16.6 | 8.3 | 6.70 | 6.05 | 14 | 1.3 | 6.1 | 6.32 | 6.33 |
| 5 | 2.5 | 7.2 | 6.90 | 6.42 | 15 | 9.7 | 6.3 | 6.32 | 6.33 |
| 6 | 6.9 | 7.1 | 7.00 | 6.62 | 16 | 11.1 | 6.6 | 6.37 | 6.37 |
| 7 | 2.0 | 6.4 | 6.80 | 6.56 | 17 | 9.8 | 6.8 | 6.44 | 6.41 |
| 8 | 7.3 | 6.5 | 6.70 | 6.56 | 18 | 6.8 | 6.8 | 6.50 | 6.45 |
| 9 | 3.8 | 6.2 | 6.55 | 6.48 | 19 | 6.1 | 6.77 | 6.54 | 6.48 |
| 10 | 5.2 | 6.1 | 6.43 | 6.41 | | | | | |

*Graphical method of determining normals.*—The most practical and, ordinarily, sufficiently accurate method of obtaining the normal is by a graphical process, which consists in plotting the 10, 15, 20, 25, etc., year averages and determining by the eye with the aid of a rubber band the position of the horizontal line of best fit. If the early averages are abnormally high or low as compared with the later averages, they should be ignored in estimating the position of the line.

The assumption on which this is based is that the trend of the data is linear and horizontal in most cases, and those records that persistently depart from such characteristics should be regarded as exceptional or fortuitous, with the probabilities in favor of the nonhomogeneity of the record. An extreme variation of 25 to 30 per cent of the normal, such as the Brückner variation, should not be regarded as indicating a nonlinear trend.

*Explanation of Figure 1.*—Figure 1 illustrates graphically the application of the method to the computation of the normal annual temperature at Washington. The accumulated temperature is shown as a heavy line, and the line of best fit to the data, that passes through the origin, is represented by the dotted line. This line represents the general trend of the data, which is seen to be a linear one. It is evident that the arithmetic average, which is the sum of all the data divided by their number, is the equivalent of the slope of the line joining the origin and the last dot, and will, therefore, only occasionally coincide with the normal, which is represented by the line of best fit to all the data.

The normals by the three methods are shown plotted with the same scale. It is seen that the fluctuations of the line of arithmetic averages about the true normal coincide with those of the line of accumulated tempera-

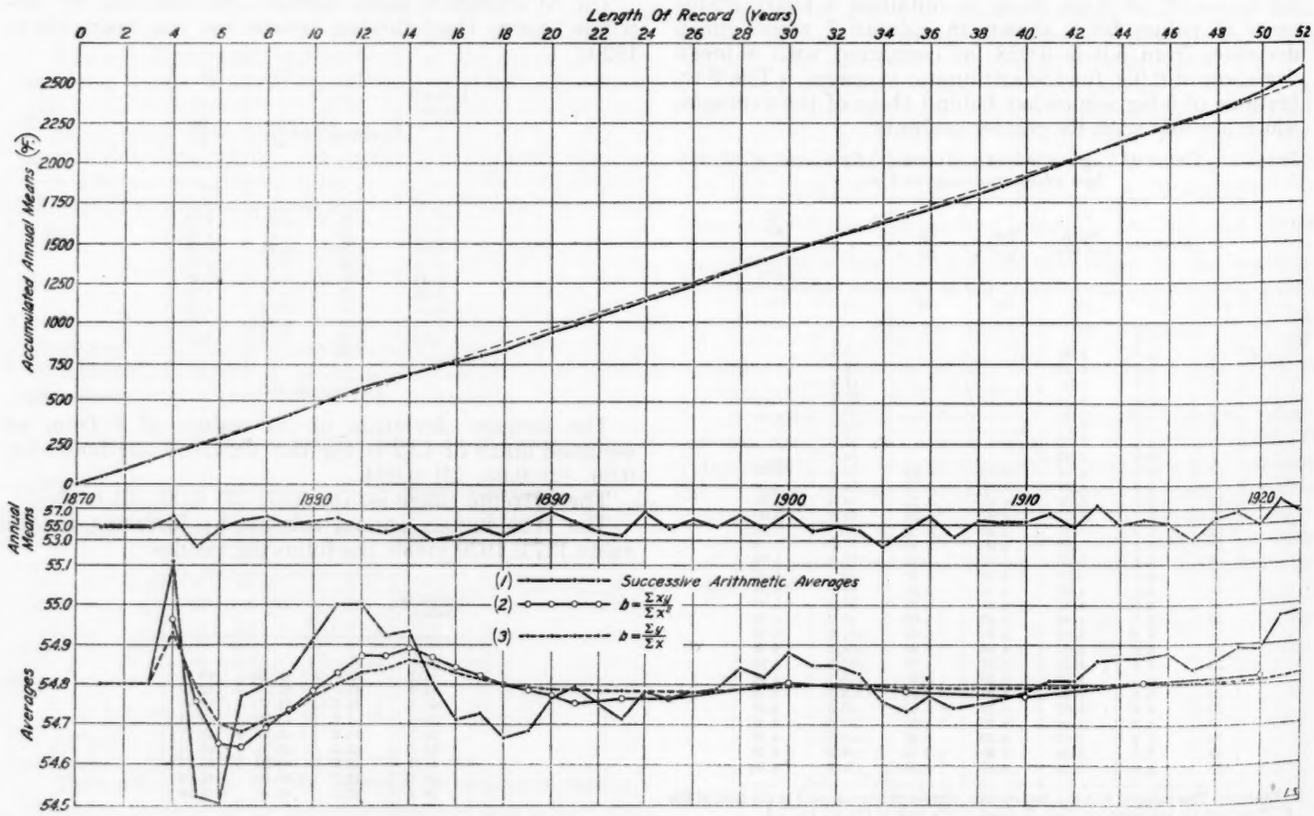


FIG. 1.—Mean annual temperature at Washington, D. C., accumulated temperatures, and normals computed by three methods.

tures with respect to the line of best fit, and satisfactorily represent them on a larger scale. The line fluctuates above and below the line of 54.8 with a gradually decreasing range. In later years, however, there is a markedly abnormal departure of the line from the line of best fit. To what extent this represents a real departure from a linear, horizontal trend, or whether it is only a temporary departure, can not now be determined.

The fluctuations of the normals computed by methods (2) and (3) illustrate the characteristics previously pointed out. Those of (2) follow more closely the averages, with, however, a lag of variable amount, increasing with length of record.

The reason for regarding these values as the best available approximation to the normal lies in the fact that large departures of the averages from the computed normal, as in 1882, 1888, 1900, 1905, and 1916 are likely to be only temporary. In the case of the persistent departures above normal in the latter years we have no reason to assume that there will not be later on a return to averages below normal, and hence are not justified in disregarding the normal as computed. If, however, the abnormal conditions persist, the computed normals will gradually be adjusted to the change. The values by method (3), being more stable, should be regarded as the best approximation to the true normal.

The essence of the method consists in the assignment of relatively less weight to the latter values of a series, which insures greater stability. It must not be regarded, however, as an improvement on the ordinary method of averaging for a short series, or before the averages have become fairly stable.

## HOURLY PRECIPITATION AT SYRACUSE, N. Y.

By MORGAN R. SANFORD, Meteorologist.

[Weather Bureau, Syracuse, N. Y.]

Popular interest in the study of rainfall distribution over the 24 hours of the day appears to be growing. Among other questions the following are being asked: "Does the total rainfall during the morning usually exceed that during the afternoon?" and "Is it more liable to be rainy in the morning or in the afternoon?" Careful examination of records covering several years has furnished considerable interesting information.

Pioneer work in this field was done by Blanford for Calcutta and by Draper for New York City.[1] Using seven-year periods prior to 1885, both of these found that the amount of rainfall was greater from noon to midnight than from midnight to noon. Fassig, using a 10-year period ending with 1902, has shown the same to be true regarding Baltimore.[2] He takes the months separately and shows the emphasis in the warmer months and the evident influence of the thunderstorm. Cox and Armington have shown the same true for Chicago over a 10-year period ending with 1911[3]. That there is considerable variation over the United States with respect to the relative amounts of daytime and nighttime rainfall has been shown by Kincer [4] in his study of a 20-year period ending with 1914. The rainfall from 8 p. m. to 8 a. m. over central New York, April to September, inclusive, he shows to be about 45 per cent of the total, while that over central Nebraska is 65 per cent of the total amount.

Hourly rainfall may be considered not only with respect to frequency and amount, but also with regard to duration, that is the length of time that rain may be falling during each of the 24 hours. Mindling has made a study of this latter subject for Philadelphia[5] and shown its importance in its direct relation to outdoor activity. Although both are important, attention is directed in this connection not to frequency nor duration of rainfall, but is confined solely to hourly amounts. Since some of of the precipitation during early April and late November at Syracuse, N. Y., is in the form of snow that interferes with the operation of the tipping-bucket rain gage, it has been thought best, for the sake of accuracy, to confine this study to the months from May to October, inclusive.

The rainfall for each of these months during the 20-year period, 1903–1922, has been considered separately, and the totals shown in the table and accompanying chart represent the accumulated depth in inches for each hour of the 24. The hourly totals for the six months are also indicated.

TABLE 1.—*Total hourly rainfall, 1903 to 1922, Syracuse, N. Y.*

| | May to October, inclusive. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| May: | | | | | | | | | | | | |
| A. M. | 3.69 | 2.07 | 2.15 | 2.29 | 1.66 | 2.04 | 2.77 | 2.08 | 1.91 | 1.40 | 2.08 | 2.27 |
| P. M. | 1.54 | 1.84 | 2.04 | 2.68 | 3.20 | 3.37 | 3.52 | 3.19 | 2.51 | 2.74 | 2.57 | 2.26 |
| June: | | | | | | | | | | | | |
| A. M. | 1.82 | 2.54 | 2.43 | 2.33 | 2.49 | 3.43 | 3.74 | 2.95 | 3.10 | 2.21 | 2.49 | 2.97 |
| P. M. | 2.66 | 5.28 | 3.91 | 4.71 | 8.20 | 4.26 | 3.65 | 3.97 | 4.80 | 3.70 | 3.30 | 2.54 |
| July: | | | | | | | | | | | | |
| A. M. | 1.10 | 0.92 | 1.47 | 1.84 | 1.90 | 1.90 | 2.16 | 1.81 | 2.25 | 1.58 | 2.00 | 3.42 |
| P. M. | 3.29 | 3.10 | 5.21 | 4.07 | 3.86 | 6.05 | 5.63 | 6.25 | 2.22 | 2.47 | 1.27 | 1.47 |
| August: | | | | | | | | | | | | |
| A. M. | 1.77 | 2.66 | 3.02 | 2.75 | 2.16 | 2.64 | 2.78 | 2.00 | 1.37 | 1.56 | 2.47 | 2.18 |
| P. M. | 1.54 | 4.31 | 4.63 | 3.64 | 2.50 | 4.52 | 2.82 | 4.33 | 2.36 | 1.25 | 1.93 | 1.54 |
| September: | | | | | | | | | | | | |
| A. M. | 2.67 | 2.37 | 1.73 | 3.73 | 2.06 | 1.88 | 2.15 | 2.22 | 1.54 | 1.24 | 1.22 | 1.02 |
| P. M. | 1.61 | 1.76 | 1.40 | 1.96 | 2.36 | 2.67 | 3.23 | 3.33 | 2.80 | 1.70 | 2.21 | 1.91 |
| October: | | | | | | | | | | | | |
| A. M. | 2.00 | 2.27 | 2.11 | 2.41 | 2.70 | 1.97 | 2.22 | 3.08 | 2.18 | 2.38 | 1.68 | 1.61 |
| P. M. | 1.62 | 2.21 | 1.87 | 2.05 | 1.68 | 2.98 | 3.47 | 3.14 | 3.11 | 3.18 | 2.05 | 1.66 |
| Totals: | | | | | | | | | | | | |
| A. M. | 13.0 | 12.8 | 12.9 | 15.4 | 13.0 | 13.9 | 15.8 | 14.1 | 12.4 | 10.4 | 11.9 | 13.5 |
| P. M. | 12.3 | 18.5 | 19.1 | 19.1 | 21.8 | 23.8 | 22.3 | 24.2 | 17.8 | 15.0 | 13.3 | 11.4 |

Two facts are brought out clearly in this chart of the hourly distribution of rainfall. In the first place there is an afternoon maximum and a late forenoon minimum; and secondly, this feature is emphasized in the warmer and fades out in the cooler months. Something similar

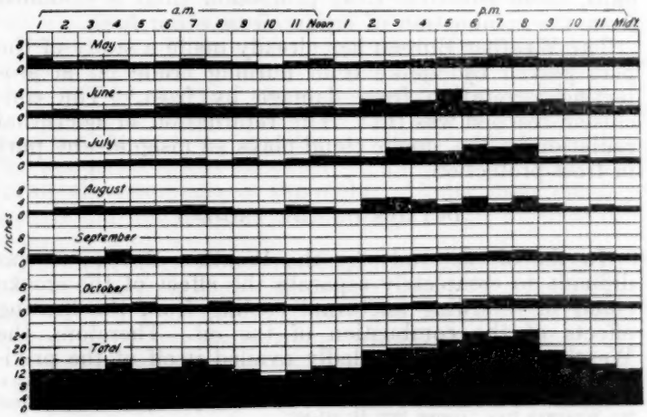


FIG. 1.—Accumulated depths of rainfall for each hour and for each month, May to October, at top and for the six months at bottom.

[1] American Weather, by Gen. A. W. Greely, p. 155.
[2] Oliver W. Fassig in Maryland Weather Service, Vol. II, p. 165.
[3] The Weather and Climate of Chicago, by Prof. Henry J. Fox and J. H. Armington, p. 203.
[4] Joseph Burton Kincer, MO. WEATHER REV., November, 1916, 44: 628–633.
[5] George W. Mindling, MO. WEATHER REV., November, 1918, 46: 517–520.

has also been shown by Nunn to be true in the rainfall of Nashville, Tenn.[6] Though on a slightly different basis, these Syracuse results agree closely with Kincer's calculation. The amount of rainfall over this period for the 12 hours ending at 8 a. m. is 45 per cent of the total, but for the 12 hours, midnight to noon, only 42 per cent of the total amount. Considering individual hours it is found that the hour ending at 10 a. m. receives the least amount and the hour ending at 8 p. m. the greatest, 2.2 times as much as the former. The three hours ending at 8 p. m. receive twice as much as the three hours ending at 11 a. m.

These results are what are naturally to be expected as effects of the forenoon warming and afternoon cooling combined with the occurrence of thunderstorms. In general, the month with the greater number and the more energetic thunderstorms has the greater afternoon rainfall. The hump shown in the June record is due in part to a violent storm on the 17th in 1922, when 2½ inches of rain fell between 4 and 5 p. m.

In marked contrast with the preceding summer is that of 1923, with a few thunderstorms and those of little energy, frequently with faint thunder and light rainfall. The total rainfall during six separate thunderstorms in August was 0.30 inch, and the greater portion of the rainfall during the summer months came during the forenoon hours, this being 58 per cent of the total amount.

These results have led the writer to two definite conclusions: In the first place, that the summers of 1922 and 1923 show opposite extremes in convectional and electrical conditions as well as in rainfall amount and hourly distribution; and secondly, that a period much longer than 20 years should be covered in order to make possible any satisfactory discussion of rainfall.

[6] Roscoe Nunn, MO. WEATHER REV., April, 1922, 50: 180–184.

## EFFICIENCY OF SMOKE SCREENS AS A PROTECTION FROM FROST.

By H. H. KIMBALL, Meteorologist, Weather Bureau, and B. G. MACINTIRE, U. S. Chemical Warfare Service.

[Washington, August 23, 1923.]

SYNOPSIS

At Edgewood Arsenal, Md., a field was covered with dense smoke, by burning white phosphorus, on nights when conditions favored frost. The temperatures were carefully measured under and in the smoke, and also in a similar nearby field that was free from smoke. Also, the rate at which heat was radiated from a blackened surface exposed horizontally was measured both under and outside the smoke cloud.

The results show that while the smoke cloud decreased the rate of cooling of the blackened surface about-one half, it had little effect upon the air temperature, probably because of an interchange between the air under the smoke and that outside. The slight increase in temperature noted under and in the smoke apparently was due principally to heat imparted to the air by the hot particles constituting the smoke.

The experiments confirm previous conclusions that the most efficient and economical method of frost protection is to heat the lower layers of the air by burning some form of cheap fuel.

The cost of maintaining a dense smoke cover over a field by burning white phosphorus, or by any other known chemical means, is greater than the cost of heating the air in the field by burning crude oil.

### INTRODUCTION.

Since the close of the World War numerous inquiries have been addressed to both the Weather Bureau and the Chemical Warfare Service relative to the practicability of utilizing a smoke cloud, such as is used to hide the movement of troops, in protecting orchards and tender vegetation generally from frost. There seems to be a conviction in the minds of many who have had to do with smoke screens that a chemically produced smoke cloud would furnish a cheaper, cleaner, and, perhaps, more effective, frost protection than is obtained from the combustion of crude oil or other fuels.

The Weather Bureau has already made a study of the part played by smoke from burning crude oil in protecting vegetation from damage by frost.[1] The conclusion reached was that "The retardation of nocturnal radiation by the smoke cloud plays an insignificant part in frost protection."

### DETAILS OF THE PROJECT.

In the above study by the Weather Bureau it was difficult to completely separate the effect of the smoke cloud in retarding nocturnal cooling from the heating effects of the combustion of the oil. Therefore, the Weather Bureau very gladly availed itself of the privilege extended to it by the Chemical Warfare Service of utilizing the facilities of the Edgewood Arsenal, Edgewood, Md., in conducting jointly with that Service experiments on the efficiency of smoke in retarding nocturnal cooling.

This cooperative project called for the maintenance by the Chemical Warfare Service of a dense smoke cloud for a period of about four hours over an area of approximately five acres on a night with little or no wind and a clear sky. The cloud was to be produced by such material as would most economically give the desired results, and in such a manner that the heating of the air by the combustion of material would be a minimum.

On its part the Weather Bureau was to determine the extent to which nocturnal cooling was retarded by the smoke cloud on nights when the meteorological conditions were favorable for frost formation.

### EXPERIMENTAL FIELD SELECTED.

The field used in carrying out the tests was selected from the standpoint of convenience in handling the equipment and raw material required and is designated "M" field. The "M" field is located on the Gunpowder River, surrounded by woods on three slides. Two areas, of a few acres each, separated by a few trees and located about one quarter mile from the water front on "M" field, were selected for the installation of the instrument shelters to be referred to later.

### SOURCE OF SMOKE.

White phosphorus was used as the smoke-producing material in all tests, as white phosphorus was readily available in sufficient quantities and as it had the property of producing more smoke per unit weight than other materials.

When phosphorus is burned in the presence of air or oxygen, phosphorus pentoxide, a solid substance, is produced, which in turn readily unites with atmospheric moisture, producing meta phosphoric acid, a liquid. A phosphorus smoke cloud consists of a mixture of the two substances, (phosphorus pentoxide and meta phosphoric acid) the ratio of the two being dependent on the humidity of the atmosphere and the rapidity with which the phosphorus is burned.

[1] Kimball, Herbert H., and Young, Floyd D.: Smudging as a protection from frost. Mo. WEATHER REV., August, 1920, 48: 461–462.

### METHOD OF PRODUCING SMOKE.

A phosphorus smoke screen is produced by igniting pieces of phosphorus on the ground at definite distances. The burning phosphorus produces a white cloud having little tendency to settle due to the fineness of the smoke particles, the direction of travel being governed by the prevailing wind and air currents. In producing a smoke screen, the distance between the pieces and the quantity used at each point is dependent on the density of cloud desired and the prevailing wind velocity.

### METEOROLOGICAL EQUIPMENT.

*Wind.*—Above the roof of the headquarters building on the "M" field there is exposed a Robinson cup anemometer which records the velocity of the wind on a register in the office below. The record sheets from this register were utilized to obtain the velocity of the wind during the experiments. The wind direction was obtained from the direction of drift of the smoke cloud.

*Temperature.*—The Weather Bureau installed four cotton region instrument shelters [2] on "M" field, each shelter containing a thermograph, a maximum thermometer, and a minimum thermometer. Shelters No. 1 and No. 2 were placed in a natural basin between an orchard and woodland to the northwest of headquarters. Shelters No. 3 and No. 4 were installed in the center of a level meadow southwest of headquarters. The shelters in each field were about 75 yards apart. No. 1 was north of No. 2 and No. 3 was west of No. 4. The distance between the two fields was about 500 yards.

The instruments and shelters were installed on March 26 and removed on May 2, 1923.

The object of the above installation was, first, to ascertain if temperature conditions were alike in the two fields, and, second, to check the accuracy of the records obtained from the four thermographs, although all the instruments had been carefully standardized by the Instrument Division of the Weather Bureau.

To obtain these desired results the thermometers were read and set by an employee of the Chemical Warfare Service each morning except on Sundays, and at the same time the current temperature was read from the thermograph traces and the minimum thermometers. In Table 1 are given the means of the comparative readings.

TABLE 1.—*Temperature data from thermometers and thermographs, "M" field, Edgewood, Md., March 27 to May 2, inclusive, 1923.*

| Shelter. | Maximum. | | Mean difference. | Minimum. | | Mean difference. | Current. |
|---|---|---|---|---|---|---|---|
| | Thermometer. | Thermograph. | | Thermometer. | Thermograph. | | Thermometer minus thermograph. |
| | °F. | °F. | °F. | °F. | °F. | °F. | °F. |
| No. 1 | 60.3 | 59.2 | +1.1 | 36.6 | 37.0 | −0.4 | +0.5 |
| No. 2 | 60.5 | 59.4 | +1.1 | 37.0 | 37.0 | ±0.0 | +0.5 |
| No. 3 | 60.5 | 59.9 | +0.6 | 37.0 | 37.4 | −0.4 | +0.2 |
| No. 4 | 60.6 | 60.0 | +0.6 | 37.0 | 37.0 | ±0.0 | +0.5 |

The readings of the thermometers in the different shelters agree well among themselves, not only in the mean values, as shown in Table 1, but also in the daily readings. The thermograph records show the usual lag, due partly to friction between the register pen and the record sheet and partly to sluggishness of the thermograph bulb as compared with thermometer bulbs in reaching the temperature of the surrounding air.

In the present investigation we are especially interested to know if the thermograph traces obtained in the different shelters are identical from day to day. Superposition of one record over another on a sheet of glass with a bright light behind it shows that they are nearly so.

*Radiation.*—In connection with these experiments two pyrgeometers [3] were installed in such positions that one of them could be kept under the smoke cloud while the other was free from it. From their readings the extent to which nocturnal radiation is diminished by the smoke cloud may be determined.

### METEOROLOGICAL DATA OBTAINED.

Since suitable meteorological conditions were necessary for the successful carrying out of the desired tests, the forecaster on duty at the Weather Bureau was asked to give notice by 10 a. m. when clear weather with light winds and nocturnal cooling that would carry the minimum temperature to or near frost conditions could be expected on the following night. This was to enable representatives of the Weather Bureau to reach the "M" field at Edgewood, 70 miles from Washington, in season to set up the apparatus for measuring the intensity of nocturnal radiation and for the Chemical Warfare Service to prepare to produce the smoke cloud.

Following the advice of the forecaster tests were attempted on the four nights April 9–10, 19–20, 25–26, and May 1–2, 1923.

On April 9–10 the sky was clear and the temperature decreased from a maximum of 50.0° F. on the 9th to 29.5° F. on the morning of the 10th. An attempt was made to cover the field containing shelters No. 1 and No. 2 with smoke, leaving the field containing shelters No. 3 and No. 4 free from smoke. Unfortunately, however, while the wind movement averaged only one to two miles per hour, it was so variable in direction that shelters No. 1 and No. 2 could not be kept continuously covered with smoke. Neither was it possible to keep one pyrgeometer under the smoke cover and the other clear of it, except for a short time at about 4:50 a. m. The pyrgeometer radiating to the clear sky then showed a loss of heat at the rate of 0.123 gram-calories per minute per square centimeter of horizontal surface, while the instrument radiating to the smoke cloud showed a loss at the rate of 0.074 gram-calories per minute per square centimeter, or only 60 per cent as much as to a clear sky.

At this time psychrometer readings showed that the air near the ground had a temperature of about 28° F., and was nearly saturated with moisture.

On April 19–20 there were a few clouds near the western horizon at sunset which increased rapidly, so that by 11 p. m. the sky was about seven-tenths covered with A. Cu. clouds, which later nearly covered the sky. The wind was from 5 to 10 miles per hour from the south. The temperature was about 48° F., and changed but little during the remainder of the night. Under these conditions it did not seem advisable to go to the expense of producing a smoke cloud.

The night of April 25–26 was cloudless, with from 6 to 10 miles of wind from the north to northwest. The temperature fell from a maximum of 68° F. on the 25th to a minimum of 41° F. on the morning of the 26th.

[1] Descriptions of these shelters are given in *Instrument Division Circulars B* and *C*, publications of the Weather Bureau.

[3] For a description of the pyrgeometer see MO. WEATHER REV. for February, 1918; 46. 57.

A smoke cloud was maintained over the field containing shelters No. 3 and No. 4 from 9:30 p. m. on the 25th to 1:15 a. m. of the 26th. Table 2 gives the pyrgeometer readings taken, with instrument No. 2 in the field that was covered with smoke and instrument No. 3 on somewhat higher ground to the north (windward) of the line of burning phosphorus that produced the smoke. A few readings of No. 2 were taken before the smoke cloud was produced, and a few more after it had disappeared.

TABLE 2.—*Nocturnal radiation measurements, "M" field, Edgewood, Md., April 25–26, 1923.*

| Time. | Pyrgeometer No. 3. Clear sky. | Pyrgeometer No. 2. Under smoke. | Assmann psychrometer. Dry. | Assmann psychrometer. Wet. | Vapor-pressure. | Remarks. |
|---|---|---|---|---|---|---|
| Apr. 25: | *Gr. cal.* | *Gr. cal.* | *°F.* | *°F.* | *Inches.* | |
| 8:55 p. m. | ..... | 0.162 | ..... | ..... | ..... | |
| 9:00 p. m. | 0.163 | ..... | ..... | ..... | ..... | |
| 9:17 p. m. | ..... | 0.162 | ..... | ..... | ..... | |
| 9:20 p. m. | ..... | 0.162 | ..... | ..... | ..... | |
| 9:21 p. m. | 0.168 | ..... | 52.7 | 42.0 | 0.143 | |
| 9:22 p. m. | ..... | ..... | 52.4 | 41.8 | 0.146 | |
| 9:30 p. m. | 0.157 | ..... | ..... | ..... | ..... | First smoke, 9:30 p. m.; second line of fire, 9:37 p. m.; third line, 9:49 p. m. |
| 9:50 p. m. | ..... | 0.151 | ..... | ..... | ..... | |
| 9:59 p. m. | 0.173 | ..... | ..... | ..... | ..... | |
| 10:17 p. m. | ..... | 0.143 | 50.0 | 40.2 | 0.139 | |
| 10:19 p. m. | 0.157 | ..... | ..... | ..... | ..... | |
| 10:43 p. m. | ..... | 0.109 | ..... | ..... | ..... | |
| 10:49 p. m. | 0.170 | ..... | ..... | ..... | ..... | |
| 11:11 p. m. | ..... | ..... | 46.3 | 39.0 | 0.154 | |
| 11:24 p. m. | ..... | 0.081 | ..... | ..... | ..... | |
| 11:27 p. m. | 0.162 | ..... | ..... | ..... | ..... | Smoke cloud continuous. |
| 11:32 p. m. | ..... | ..... | 46.0 | 39.0 | 0.157 | Moon, but no stars, visible through it. |
| 12:00 midnight. | ..... | 0.082 | ..... | ..... | ..... | |
| Apr. 26: | | | | | | |
| 12:11 a. m. | 0.135 | ..... | ..... | ..... | ..... | |
| 12:17 a. m. | ..... | ..... | 42.0 | 37.2 | 0.167 | Bulb of psychrometer 4 inches from ground. |
| 1:15 a. m. | ..... | 0.102 | ..... | ..... | ..... | Smoke ended 1:15 a. m. |
| 1:21 a. m. | 0.125 | ..... | ..... | ..... | ..... | No smoke. |
| 1:27 a. m. | ..... | 0.135 | ..... | ..... | ..... | Increasing wind. |
| 1:40 a. m. | ..... | ..... | 45.0 | 38.2 | 0.158 | |
| 1:42 a. m. | ..... | ..... | 44.5 | 38.0 | 0.157 | |

The effect of smoke in diminishing the loss of heat by radiation from the instrument to the atmosphere is very clearly seen in these readings. With the densest smoke it is diminished one half, and the readings became comparable to those obtained on April 19–20 with the sky nearly covered with clouds.

A comparison of the thermograph traces in the different shelters shows no appreciable difference between the temperatures in shelters No. 1 and No. 2 outside the smoke cloud, and in shelters No. 3 and No. 4 under the smoke cloud.

On May 1 Cu. St. clouds commenced to form before sunset, the sky became overcast by 8 p. m., and light rain fell for a few minutes. The clouds commenced to break soon afterward, and at 9:30 p. m. preparations were made to cover the field containing shelters No. 3 and No. 4 with smoke.

A smoke cloud was maintained from 10:52 p. m. to 2:15 a. m. of May 1–2. About 800 pounds of white phosphorus was used on a 66-yard front in the presence of an average wind of three miles per hour. The cloud rose at the firing point until the base of the cloud was about seven feet above the ground, then slowly dispersed downward, reaching the ground at the 40-yard line. The top of the cloud reached a maximum height of 40 yards at the 300-yard line but did not increase in height beyond this point.

On following the cloud down its course, it was observed that a heavy screen was produced for a distance of about 200 yards from the line of fire, but the density decreased beyond this point.

The intensity of nocturnal radiation was measured, but on account of the presence of clouds during most of the time no great interest attaches to the readings. A few measurements made with a nearly cloudless sky show that the radiation to the clear sky was about twice as intense as to the dense smoke cloud.

The thermograph traces show little decrease in temperature in any of the shelters during the time No. 3 and No. 4 were under the smoke cloud. Indeed, the two latter indicate a slight rise in temperature, as a comparison of the thermograph traces obtained in shelters 2 and 4, given in Figure 1, shows.

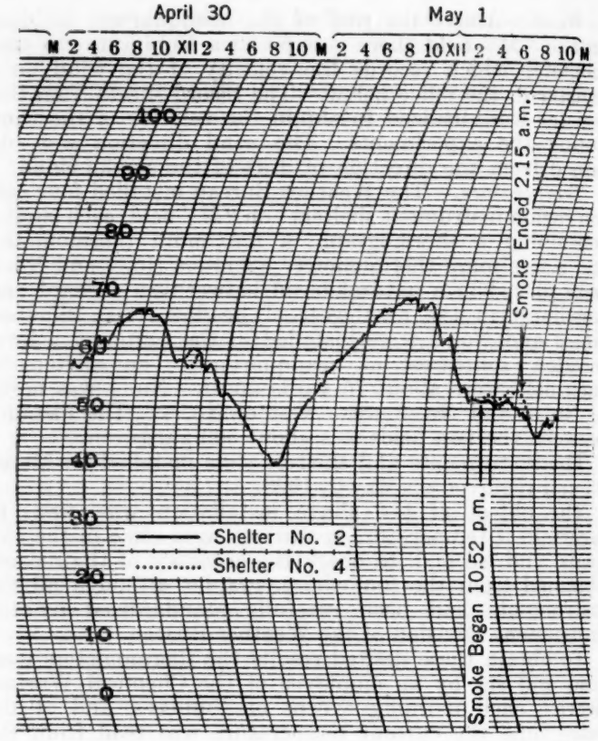


FIG. 1.—Thermograph traces, "M" field, Edgewood, Md., April 30–May 2, 1923.

Advantage was taken of the favorable wind conditions and the resulting form of the smoke cloud to carefully measure with an Assmann psychrometer the horizontal temperature gradient from the line of fire to the line of instrument shelters No. 3 and No. 4. The results are given in Table 3.

TABLE 3.—*Temperature variation with distance from burning phosphorus (temperature at line of shelters taken as standard), "M" field, Edgewood, Md., May 1–2, 1923.*

| | Distance from fire (feet). | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 135 | 100 | 75 | 50 | 30 | 12 | 10 | 8 | 6 | 4 | 2 |
| | °F. | °F. | °F. | °F. | °F. | °F. | °F. | °F. | °F. | °F. | °F. |
| Under smoke | 0 | −0.3 | −0.3 | −0.8 | +0.7 | +1.0 | +1.1 | +1.5 | +1.7 | +1.0 | +7.0 |
| In smoke | 0 | ..... | +0.5 | +0.9 | +1.7 | ..... | +2.2 | ..... | +25.0 | ..... | +30.0 |

The first line of temperature variations shows the departures from the temperature at the line of the shelters, measured by the dry bulb of an Assmann psychrometer, when held at about the height of the eye while kneeling. The temperature at this point was measured in the smoke cloud. The temperature at other points was generally measured under the cloud.

The second line of temperature variations represents readings taken with increased wind movement that beat the smoke down to the ground, perhaps by hastening its cooling, practically all the way from the burning phosphorus to the instrument shelters.

It will be noticed that under the cloud the lowest temperatures were obtained at about one third the distance from the fire to the shelter, or where the base of the smoke cloud was probably the highest. In the smoke cloud the temperature decreased gradually from the fire to the shelters.

At 2 a. m. on May 2 the edge of the smoke cloud was near shelter No. 4 and sharply defined. Outside this cloud the temperature near the ground was 2.1 °F. lower than in the dense cloud at the shelter. Somewhat nearer the shelter in thin cloud it was 1.5 °F. lower; and back of the line of fire it was 3.1 °F. lower.

### INTERPRETATION OF THE METEOROLOGICAL DATA.

The horizontal temperature gradients shown in Table 3, and especially the decrease in temperature at 2 a. m. of May 2 from the smoke cloud to points outside the cloud, show very clearly the effect of the smoke in retarding nocturnal cooling. That this is not entirely due to a diminution in the intensity of radiation from the ground to the atmosphere is indicated by the fact that in the first line of temperature departures of Table 3 the lowest temperature was found at the point where the base of the smoke cloud was the highest, and also by the fact that in the second line of temperature departures, where all the measurements were made in the cloud, the temperature decreased with distance from the line of fire.

Evidently heat is conveyed to the air by the particles constituting the smoke. This is more clearly shown in measurements made a few feet from the fire, where they were markedly higher in the smoke than just below it.

We may conclude, then, that the slightly higher temperature recorded between midnight and 2:15 a. m. of May 2 in shelters No. 3 and No. 4 as compared with that recorded in shelters No. 1 and No. 2, was due in part at least to heat conveyed to the air by the heated particles constituting the smoke.

That practically no retardation of nocturnal cooling was noticeable in the smoke cloud of April 25–26 is in accord with the results of investigations on cloth screens,[4] which, briefly summarized, show that:

> Cloth coverings over small areas of orchard or over individual trees do not have an appreciable effect on the temperature, even when the coverings are of heavy cloth or canvas. This is due to the fact that the cloth does not prevent an interchange between the air under the covering and that outside.
>
> Coverings of rather heavy cloth laid directly over garden truck or low-growing plants are effective in protecting against moderate frosts.

In the case of all the smoke tests described in this report, a similar interchange of air undoubtedly took place on account of the relatively small firing front and the short distance between the edge of smoke and the instrument shelters. Only in cases of practically no wind velocity could one expect the blanketing effect of the smoke screen on the earth's radiation to affect the temperature of the air near the ground, and in such cases it is very difficult to set up a uniform smoke cloud over an area.

We may compare the results of the above tests with temperature records given by Young,[5] which show that the temperature in an orchard heated by the combustion of crude oil is frequently 5° higher than in an orchard unheated.

[4] Young, Floyd D.: Frost and the prevention of damage by it. U. S. Department of Agriculture, *Farmer's Bulletin No. 1096*, p. 12.
[5] Young, Floyd D.: *Loc. cit.* pp. 15, 26, 27, 29.

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The above results strengthen the conclusion already expressed that "The retardation of nocturnal radiation by the smoke cloud plays an insignificant part in frost protection."

### COST OF HEATING AN ORCHARD.

Young[6] also gives estimates of the cost of protecting orchards in southern California from frost by heating with crude oil.

Briefly summarized, the average annual cost per acre of protecting 220 acres of lemon trees for the 6-year period 1913–1918 was $78.90. Fires were lighted an average of 16 times each year. The average annual cost per acre of protecting 40 acres of orange trees, requiring fewer firings than the average orchard, was $26.65

The above estimates include interest on cost of installation, depreciation of equipment, fuel, and labor, at a time when prices averaged about one-half what they do at present.

### COST OF PHOSPHORUS SMOKE SCREEN.

A dense smoke screen can be produced by burning phosphorus at the rate of 1.25 pounds per hour per yard of front screened in the presence of a 1-mile-per-hour wind. It is estimated that after forming a screen of sufficient density, this density may be maintained by reenforcing the cloud with a 10 per cent addition of smoke at intervals of 200 yards measured in the direction of cloud travel.

For example, a 40-acre orchard, having a front of 220 yards and depth of 880 yards would require 275 pounds of phosphorus per hour on the front line in the presence of a 1-mile wind and 28 pounds additional every 200 yards measured from the firing front down the length of the orchard. A total of four lines of fire would have to be maintained as follows:

| | Pounds per hour. |
|---|---|
| Front line | 275 |
| 200-yard line | 28 |
| 400-yard line | 28 |
| 600-yard line | 28 |
| Total | 359 |

In the presence of a 2-mile wind, the consumption would be twice as great, the increase in consumption being in direct proportion with increase in wind velocity.

With phosphorus at 35 cents per pound, the phosphorus costs of screening a 40-acre orchard per hour would be as follows:

| Wind velocity, miles per hour. | Pounds of phosphorus. | Cost of material. |
|---|---|---|
| 1 | 359 | $125.65 |
| 2 | 718 | 251.30 |
| 3 | 1,077 | 376.95 |

Two men would be required to handle the phosphorus at the first firing front and one man additional at each point of reenforcement, making a total of five men. In the presence of a 2-mile wind, about six men would be required, three on the first line and one each on the other three lines.

It is quite evident from the above figures that the cost of covering an orchard with smoke by the use of phosphorus is very much in excess of the cost of heating it by burning petroleum.

It should also be remembered that white phosphorus must be handled with extreme care, as it ignites when exposed to air at a temperature of 113° F. It should be transported under water in metal containers and handled with rubber gloves.

[6] *Loc. cit.* pp. 33-34.

## CLOUD DISSIPATED BY KITE.

J. A. RILEY, Meteorologist.

[Weather Bureau Office, Broken Arrow, Okla., Sept. 14, 1923.]

On July 29, 1923, during a kite flight at the Broken Arrow, Okla., station one of the kites caused a rift in a layer of thin clouds as the kite was being lowered through it. This phenomenon may be of interest in connection with recent reports of rain making and cloud dissipating by airplane.

The clouds on this morning were predominately alto-cumulus with some patches of very small fleecy balls that would have been recorded as cirro-cumulus from their appearance had not their altitude been determined by the kites. A very thin alto-stratus veil spread among the more compact masses of alto-cumulus.

The kites were obscured by this thin cloud layer as they were being reeled in, when presently one of the kites cast its shadow on the clouds; this shadow was visible to the observers at the reel house for perhaps two minutes. Then the kite entered the cloud stratum and a rift in the cloud began. It rapidly lengthened in the lee of the kite and looked as if the kite were a plow making a long straight furrow in the cloud. The opening was somewhat wider than the kite and more than 2,000 feet long as determined by angular measurements, when it was closed by the kite being lowered out of the cloud. The rift was visible as a straight dark line for several minutes afterward as it drifted away.

Contrasted with this dissipating of clouds is the formation of cloud bands by the passage of airplanes through previously clear air of high humidity, as recorded in "The Argonne Battle Cloud."[1] The two processes are not necessarily related however. The evaporation of the cloud particles is undoubtedly the result of the deflective action of the kite on the air passing through it.

The clouds were 2,800 meters high, with a velocity of 8 m. p. s. from the west, and a temperature of 7° C. (45° F.). Below the cloud there was a nearly normal lapse rate of temperature; above there was a sharp but limited inversion. As the kite entered this inversion layer this warm air was deflected down into the cloud with the result that the cloud particles were evaporated.[2]

The total amount of cloudy condensation evaporated was, of course, relatively small; it is only because the cloud stratum was very thin that an opening in it was made. Usually the clouds are far too thick to be affected by the small deflection in the air caused by the kite.

Streaks in the clouds have previously been observed during kite flights, twice at Mount Weather, Va., and once each at Drexel, Nebr., and Ellendale, N. Dak.[3]

Mr. V. E. Jakl states that—

> This phenomenon has come under my observation twice. In the case of Drexel on July 9, 1917, and at Ellendale on January 15, 1918, we find in the former case an abrupt inversion and drop in humidity at about the level where the streak started downward. In the Ellendale case, the tabular record shows no inversion, but shows increasing humidity and formation of alto-cumulus up to the level where the streak was observed to begin. In both these cases it appears that the kite was far below the cirro-stratus in which the streak was observed. However, what appeared to have been a streak in the cirro-stratus might have been simply greater visibility developing in a line in a thin stratum of air where cloudiness was incipient, this greater visibility evidently caused by the evaporation of the tenuous clouds, similar to the dissipation of the actual clouds observed at Broken Arrow.
>
> The electrical theory mentioned by Dr. Blair (MO. WEATHER REV., June, 1917) seems plausible enough, in the light of recent experiments on dissipation of clouds by charged sand, but has the objection that if this were so we would observe the streak phenomenon more often, and when observed, it should be more permanent.

[1] MO. WEATHER REV., June, 1921.

[2] At the cloud level the lapse rate was about 0.9° C. per 100 m. as shown by the record, or approximately adiabatic. Hence the atmosphere at this level was nearly in neutral equilibrium. Clearly, then, the downward deflection of the air carried that portion of the cloud just beneath the kite to a considerably lower and warmer level. Furthermore the loss of heat, due to the evaporation of the depressed cloud, slightly increased the distance of fall and consequent ultimate warming of the descending air.—*W. J. H.*

[3] MO. WEATHER REV., June, 1917. 45: 269-270; and SUPPLEMENTS No. 11, p. 5, and No. 12, p. 6.

## FORECASTING RAIN ON THE WEST TEXAS COAST.

JOSEPH P. MCAULIFFE, Meteorologist.

[Weather Bureau, Corpus Christi, Tex., Sept. 6, 1923.]

Rainfall, the most important meteorological element in most regions, becomes doubly important on the west coast of Texas, since the relatively small amount received annually bears an important relation to the yield of crops. It is very important, therefore, that weather forecasters have a thorough knowledge of the subject in order that those rather infrequent rains may be accurately forecast for the benefit of farmers.

An effort has been made by the writer to determine the character of the atmospheric disturbances that most frequently cause precipitation in this region, and to this end a careful study of the most important rains has been made, the period under discussion being the years from 1902–1922, inclusive. Only the rains that were of material benefit to crops have been selected, those amounting to 1 inch or more in 24 hours.

A striking feature of these heavy rains has been the fact that the great majority of them have occurred with the prevalence of a north or northeast wind—48 per cent of the rains occurring with these wind directions. The north wind predominates with rains of 1 inch or more in 24 hours, being 28 per cent of the total. Northeast winds give 20 per cent of the rains, while east and southeast each have 18 per cent, south 9 per cent, southwest 2, west 1, and northwest 4 per cent.

The question now arises: What is the character of the atmospheric disturbance causing these heavy rains, and what location must it have with reference to this locality in order to give precipitation? In the great majority of cases the rain-producing LOW overlies the Rio Grande Valley, with a well defined HIGH to the northeast. Often a Gulf disturbance will be the cause of the great rains of this region, but these disturbances frequently move inland and become Rio Grande LOWS, so it may be assumed that the majority of the rain-producing disturbances are of the latter type. Any depression that moves far south, especially in winter, and comes through New Mexico, thence to south-central Texas, may cause precipitation on this coast, but there are many instances where the LOW will swing northeastward through northern Texas after reaching the vicinity of Roswell, New Mexico, and when this happens it becomes either a "dry LOW" for this region, or one with very little precipitation. When, however, a large HIGH impinges on one of these western LOWS in the Rio Grande Valley north and northeast winds result, with an abundance of

rainfall along the west Texas coast. It matters little what the season of the year, rainfall will almost always occur with a LOW in the Rio Grande Valley, and a HIGH over the region to the northeast.

Of course there are many exceptions to this rule, and rain may occur with a south wind, but the data for twenty years show plainly that heavy rains with southerly winds are rather rare in this region. In most cases the LOW is advancing towards the Rio Grande Valley, and will at first cause southerly winds, but soon easterly to northerly winds will set in, and then the rain will become general, heavy, and long continued.

Often the southward advance of a northwestern HIGH will cause precipitation without the presence of any well defined LOW over Texas, but with only a "relative LOW" over extreme southern Texas caused by the abnormally high pressure advancing from the Northwest. Thus it occurs that many "northers" in winter, spring, and fall are attended by general and sometimes heavy rains. Frequently these rains on the west Texas coast are little more than mists that come in with the north and northeast winds, but they often persist for several days, and cease only after the HIGH has advanced well into Texas or has passed entirely out of the western half of the country.

A peculiar feature of the influence of the sea coast on wind direction in this region is the fact that a northwest wind seldom persists for a long time. The "northers" that cause strong northwest winds in central Texas reach this coast as a northeast wind, or when sufficiently strong, cause a northwest wind for a short time, then shift to north, and finally to northeast. It is this tendency for a northwest wind to become a northeaster that causes the mists referred to above. It also tempers the cold waves, because the wind blows over the water surface when it comes from the northeast. Frost and freezing temperature are therefore prevented from reaching this coast, except in the unusually severe cold waves.

It would seem from what has been said that it is an easy matter to forecast rain on this coast, the wind direction being the principal element to consider. As a matter of fact it is rather a difficult problem until the rain begins, as it is often uncertain where the LOW will advance when it is coming from the southern Rocky Mountains, and when it comes through Mexico it may cause rain before its presence is observed. After precipitation begins it is safe to assume that it will continue until the Rio Grande Valley LOW moves out or dissipates. These LOWS are usually sluggish, therefore a forecast for 24 or 36 hours ahead is not difficult once the rain begins. Occasionally, however, they advance rapidly, and a rain forecast for a certain period will occur before the verifying period begins.

In conclusion it may be said that local forecasters in this area should remember that light and infrequent precipitation occurs on this coast except when north to east winds prevail, generally induced by a Rio Grande LOW. Forecasters, therefore, should be wary about forecasting precipitation with an advancing LOW unless the central depression is far south, generally below Amarillo, and it is expected that the depression will move into the Rio Grande Valley. On the other hand, they should not forecast a cessation of precipitation with a Rio Grande LOW until it is certain that it will move entirely out of the Valley, and this is usually a slow process when a HIGH checks it.

## WATERSPOUTS NEAR CORPUS CHRISTI, TEX.

By JOSEPH P. MCAULIFFE, Meteorologist.

[Weather Bureau Office, Corpus Christi, Sept. 18, 1923.]

A waterspout occurred over Corpus Christi Bay during the morning of September 12, 1923 under conditions that were most favorable for observation and study. Unfortunately, however, no photographs were made of it.

The phenomenon formed during a morning that had given moderate to heavy local showers and squalls. It was the first occurrence of its kind since 1917, and the most perfect waterspout that has ever been observed so close to the city of Corpus Christi. Occasionally these phenomena are seen on the Gulf of Mexico, but seldom in the bays along this coast.

The writer was on the roof of the Federal Building examining the rain-gauge when his attention was attracted by heavy peals of thunder in the northeast. A thunderstorm was approaching the station from that direction. As the squall cloud advanced rapidly a thin pendent cloud suddenly appeared, waving to and fro and twisting irregularly, much like a pennant suspended horizontally, flapping in the breeze. This was exactly 10:31 a. m. The pendent cloud extended rapidly downward, and by 10:35 a. m. had touched the surface of Corpus Christi Bay, apparently 10 miles east-northeast of the station. The column was now straight as a plumb line, intensely black, except that a thin gray streak extended throughout its center from the cloud mass to the water. The spiral motion of rotation was plainly visible, and it caused a great agitation of the water surface over which it passed, causing water and spray to rise to a height estimated at 10 feet. The direction of the spiral motion was usual for such phenomena, i. e., counterclockwise. The waterspout advanced rapidly from the northeast, breaking away somewhat from the main thundercloud, which advanced from a more easterly direction. At 10:40 a. m. the middle part of the pendent cloud made a sharp bend toward the south, leaving the upper and lower portions a little in its rear. A few minutes after this the waterspout broke into two parts, the upper part drawing up into the main storm cloud, while the lower part advanced onward toward the southwest, causing the agitation of the water surface to continue. In its last stages the only part of the waterspout visible was a twisting mass of spray moving rapidly across the bay. This disappeared when within a mile of the city and a half mile northeast of the Municipal Pier, where motorboats and skiffs were moored. This was exactly 10:44 a. m. The diameter of the waterspout was estimated at 40 feet. The entire distance traveled by the cloud after touching the water was about 12 miles, and it covered this distance in nine minutes. A sharp squall came in from the bay immediately after the disappearance of the waterspout, giving a maximum velocity of 26 miles an hour from the east at 10:46 a. m. Only 0.01 of an inch of rainfall occurred, the heavy rain area passing north of the station.

Fishermen returning from the Gulf reported having seen two waterspouts during the same day, and at different times and places. One of these was reported a few miles east of Corpus Christi Pass (about 12 miles southeast of the station), while another was seen in the Laguna Madre, probably 15 or 20 miles southeast of Corpus Christi. Neither of these was as large as the one observed over Corpus Christi Bay.

## THE FIRST COOL WAVE OF 1923 IN THE DAKOTAS AND LAKE REGION.

By ALFRED J. HENRY, Meteorologist.

[Weather Bureau, Washington, Sept. 22, 1923.]

Supervising Forecaster Bowie in his report on "Storms and Weather Warnings," this REVIEW, page 419, mentions the fact that an extensive area of high barometric pressure and cool weather spread over the Northwestern States on the 21st, this being the first occurrence of a pronounced anticyclone in the United States during the present transition season from summer to autumn.

There is, of course, no magic significance in the early or late occurrence of such events, nevertheless from the forecaster's viewpoint they almost always excite the liveliest interest and a desire to trace them back to their beginning. The occurrence of sea-level pressure of 30.40 inches in August in the northwest or elsewhere in the United States, is of itself sufficiently infrequent to merit a brief examination such as this purports to be.

I am advised by Mr. O. W. Roberts, meteorologist in charge of the Bismarck Weather Bureau Office that sea-level pressures of that amount have been recorded at his station on August 23–24, 1911; August 26, 1914; August 28–29, 1915; August 13, 1916, and August 21, 1923, or in 5 years out of 35. In practically all of these cases the increase in pressure was attended by a fall in temperature of approximately 20° F., more than the average cloudiness, and generally some precipitation. An antecedent condition in every case was the presence of an area of low pressure and high temperature over the Dakotas.

The evidence of the weather map does not support the view that in these cases polar air flows in to produce the surface cooling, as is so manifestly the case in the cold season; rather the inference is unavoidable that the cooling of the surface air and, inferentially, that for some distance above the ground is due, in great measure, to direct contact with the falling rain and indirectly to the increased evaporation that results from the wetting of the surface cover. Nocturnal radiation must be of secondary importance by reason of the very considerable cloudiness present.

I present in Figure 1 reduced copies of the Washington daily weather maps of August 21 and 22, 1923, respectively. The most pronounced features of the map of the 21st are the anticyclone with sea-level pressure of 30.40 inches, centered over the provinces of Saskatchewan and Assinaboia and the trough of low barometric pressure stretching from western Ontario to Texas. Rain has fallen over a broad band extending from Lake Superior westward to the Pacific.

So far as can be determined the anticyclone developed over the provinces above-named during the night of the 20th–21st. The barometric trough shown on the map of the 21st is the result of the eastward movement of a cyclonic system that was centered over Montana on the 20th.

The map of the 22d shows a very remarkable (for the season) deepening of the barometric trough of the preceding date and a very material change in the configuration of the isobars. An explanation of these changes is not afforded from surface conditions and none will be attempted other than to suggest that there may be and probably is a connection between the increase in pressure in the anticyclone on the 21st and the sharp fall during the night of the 21st–22d.

The records of kite flights and pilot-balloon observations on the 21st and 22d at the stations named hereinafter throw some light on the structure of the free-air column in the southeast quadrant of the anticyclone, but, as usually happens, kites could not be flown in the barometric minima that preceded it. The location of the kite stations is shown in Fig. 1.

The Ellendale and Drexel kite records of the 21st contain the material from which the following is extracted. The last-named station is about 345 miles (555 km.) more distant from the anticyclone center than the former, but nevertheless the records of both stations are in close accord. The wind direction from the surface up to about 1,500 meters (above sea level) was N.–NE., or anticyclonic, as might have been expected; it then backed to N. at about 2,000 m. and to NW. at 2,500 m., continuing from that direction up to 2,894 m., the top of the flight at Ellendale. At Drexel the direction was practically the same and the NW. wind prevailed up to 3,500 m. Anticyclonic circulation therefore did not extend much, if any, above 1,500 m. At Broken Arrow, the most southerly station used, S.–SW. winds prevailed at the surface, shifting to SW. at 500 m., W.–SW. at 1,500 m., W. at 3,000 m., and continuing in that direction at 3,536 m.

Broken Arrow was in or perhaps a little south of the center of the barometric trough before mentioned. The wind direction conforms to what might have been expected in that position. The average lapse rate in the temperature of the free air on the 21st was, for Ellendale 0.30° C., Drexel 0.38° C., and Broken Arrow 0.64° C. per 100 meters. A rather pronounced temperature inversion was encountered just above the base of the cloud level, or at about 1,500 m. at both Ellendale and Drexel on the 21st and at Royal Center on the 22d at about 1,500 m., although in the last named no clouds were present. The relative humidity was quite low in the inversion stratum.

For the 22d pilot-balloon observations are available for each of the four kite stations, all of which were within the influence of the anticyclone which was then centered over Nebraska. On the northern margin of this anticyclone, as at Ellendale, westerly winds increasing in velocity above 3.5 km. prevailed up to 6 km., the top of the flight; Royal Center on the eastern margin showed a N. wind at the surface slowly backing to W. at 6.5 km. The velocity from 0.5 to 1 km. was about 12 m. p. s. It then fell to 7 m. p. s. at 2 km., increasing to 17 m. p. s. at about 3.7 km., and continued above 16 m. p. s. from that level up to the top of the flight at 6.5 km. At Broken Arrow, on the southern margin of the anticyclone, the wind was E. at the surface, backing to W. at 2 km. and to SW. at 3.5 km. The maximum velocity was from the N. between 1 and 1.5 km. Above that level it decreased very sharply. At Drexel, nearly in the central part of the anticyclone, the surface wind was E. It backed to N. and NW. at the 1.5 km. level, and the velocity increased from 2 m. p. s. at the surface to 15 m. p. s. in the higher levels. The increase in velocity of the westerly winds is easily understood.

On the 22d pressure in the central part of the anticyclone had decreased to 30.30 inches and it soon fell to about 30 inches.

From the foregoing and the data of the daily weather map, I conclude that the air in this particular anticyclone was not descending, neither was it a mass of polar air moving equatorward, but rather it must be considered as one of many local or regional reversals which must take place in the seasonal movement of air from low to high

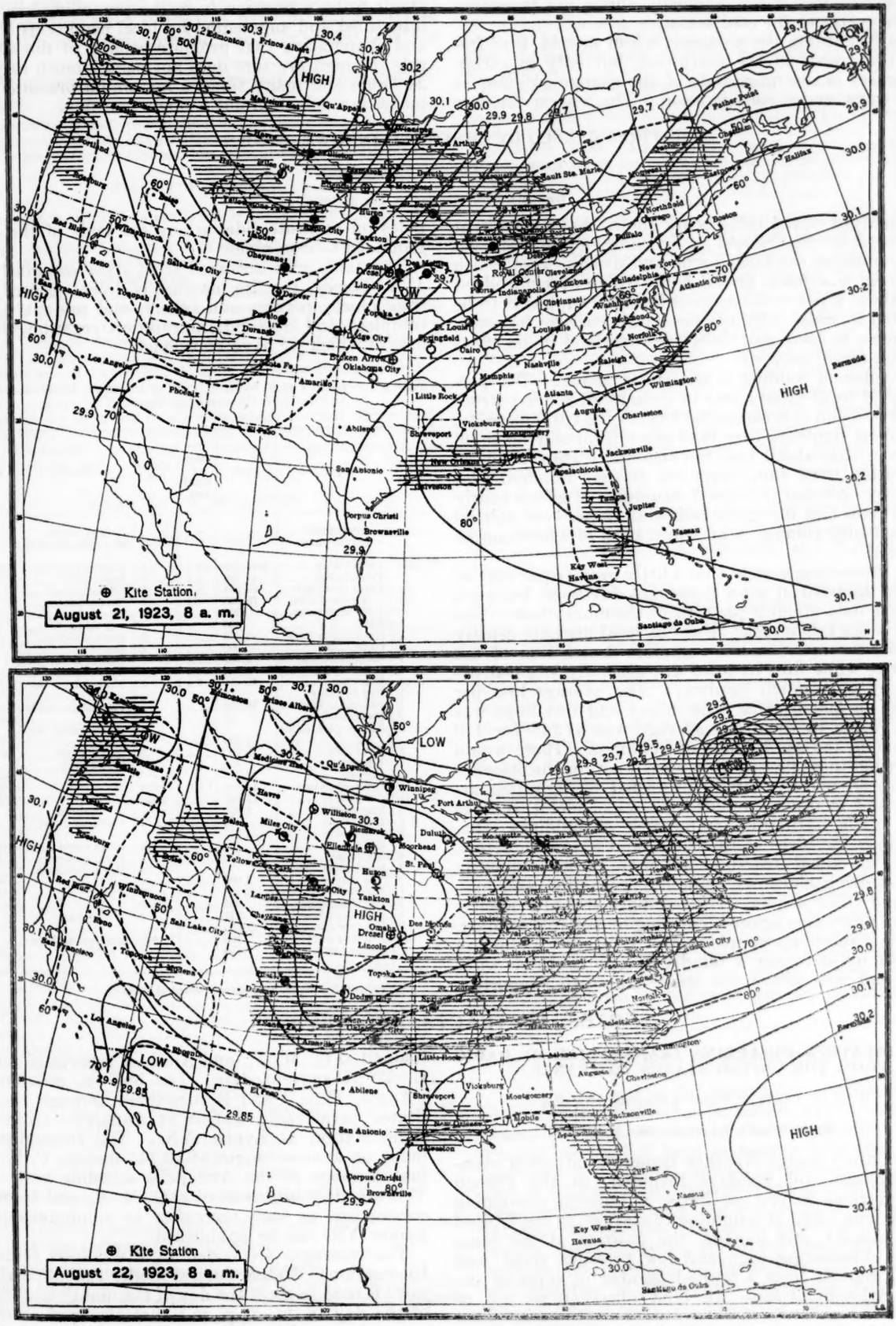


FIG. 1.—Weather maps for 8 a. m. seventy-fifth meridian time, Aug. 21 and 22, 1923.

latitudes and vice versa, especially during the transition from the warm to the cold season.

In early autumn the sequence, warm to cold, is of frequent occurrence in the northwest, but only in exceptional cases is the magnitude of the change so great as in the cases under consideration. The rise in pressure seems to be a reaction from the prevailing low pressure intensified and augmented by local conditions of rainfall and evaporation that promote cooling of the air. As a rule the high pressure does not persist much longer than 24 hours and many times a maximum pressure of 30.40 inches is reached on but a single morning.

## FIRES CAUSED BY LIGHTNING IN IOWA, 1919-1922.

By ROY N. COVERT, Meteorologist.

[Weather Bureau, Washington, Aug. 31, 1923.]

An analysis of the table below shows that 74 per cent of the total fire loss caused by lightning in four years occurred amongst the farm barns and dwellings, of which 61 per cent was due to fires in barns which were unrodded while about 6 per cent occurred in barns supposed to be protected by rods. Eight of these latter barns, however, are known to have had defective rods, and in six cases lightning ran in on wires.

The value of rodding is effectively shown. The percentage of total money loss to include all rodded structures is 6.8, and it is estimated that in the rural districts, where most lightning fires take place (probably 80 to 90 per cent), that about half the structures are rodded, so that during these four years out of each hundred fires five to six occurred in rodded structures of which nearly 20 per cent had defective rods and 15 per cent started from lightning coming in on wires, both of which can be prevented.

It is interesting to note that a little over 17 per cent of the fires occurred in town barns and dwellings, but such fires gave only about 9 per cent of the money loss. The reason is not far to seek. Fires in rural districts usually result in the more or less complete destruction of the structure, while fires in town are generally stopped before they gain much headway. The average loss per building in 390 fires in farm barns and dwellings was $2,532, while in town the average was $1,146 for 110 fires among the same kinds of buildings. There would be more lightning fires in town were it not for the presence of overhead wires generally protected by lightning arresters and to other grounded masses of metal, such as stacks, roofs, structural framework of buidings, etc., which take the place of the usual lightining conductors.

Other unrodded structures which are rather frequently fired are grain elevators, churches, granaries, and hay, grain and straw stacks. The buildings should evidently be given protection against lightning by suitable rodding, and it is a relatively simple matter to protect a stack in the field by stringing a bundle of two or three wires across and well above the stack from two supporting poles on opposite sides where the ends of the wire are grounded to iron pipes.

The table was arranged from data compiled by Mr. J. A. Tracey, the fire marshal of Iowa, secured by him from chiefs, mayors and others, and presents the most complete and detailed information regarding lightning fires of which we have knowledge.

TABLE 1.—*Details as to rodding, kind of structure, location and estimated money loss.*

| Number. | Kind. | Loss. | Per cent of total loss. | Number. | Kind. | Loss. | Per cent of total loss. |
|---|---|---|---|---|---|---|---|
| | UNRODDED STRUCTURES. | | | | UNRODDED STRUCTURES—con. | | |
| 363 | Farm barns | $894,546 | 61.1 | 2 | Railroad depots | 1,200 | ..... |
| 37 | Town barns | 49,199 | 3.4 | 1 | Restaurant | 965 | ..... |
| 27 | Farm dwellings | 92,894 | 6.3 | 7 | School houses | 7,595 | ..... |
| 73 | Town dwellings | 76,928 | 5.3 | 1 | Smoke house | 300 | ..... |
| 1 | Auto sales room | 200 | ..... | 30 | Stocks, hay, grain or straw | 5,213 | ..... |
| 1 | Bank | 400 | ..... | 3 | Storage houses | 10,864 | ..... |
| 3 | Blacksmith shop | 4,060 | ..... | 2 | Stores | 8,144 | ..... |
| 2 | Cafes | 200 | ..... | 1 | Street car | 62 | ..... |
| 1 | Carpet cleaning | 2,332 | ..... | 1 | Substation | 511 | ..... |
| 1 | Cheese factory | 7,000 | ..... | 1 | Tank-wagon station | 2,000 | ..... |
| 14 | Churches | 36,471 | 2.5 | 1 | Telephone cable box | 50 | ..... |
| 1 | Dry cleaning | 75 | ..... | 1 | Transformer station | 5 | ..... |
| 1 | Electric light plant | 26,000 | ..... | 3 | Warehouses | 1,468 | ..... |
| 2 | Factories | 65 | ..... | 1 | Water tank | 75 | ..... |
| 1 | Fair ground building | 3,000 | ..... | 629 | | 1,363,704 | ..... |
| 1 | Feed mill | 5,000 | ..... | | RODDED STRUCTURES. | | |
| 1 | Foundry | 350 | ..... | 28 | Farm barns | 81,281 | 5.6 |
| 7 | Garages | 12,716 | ..... | 6 | Farm dwellings | 17,330 | 1.2 |
| 8 | Grain elevators | 58,684 | 4.0 | 5 | Town dwellings | 1,865 | ..... |
| 11 | Granaries | 17,040 | ..... | 39 | | 100,476 | ..... |
| 3 | Hay sheds | 3,800 | ..... | | TOTAL. | | |
| 1 | Hen house | 100 | ..... | 668 | Rodded and unrodded | 1,464,180 | ..... |
| 3 | Hog houses | 3,725 | ..... | | | | |
| 1 | Hotel | 150 | ..... | | | | |
| 1 | Ice house | 2,128 | ..... | | | | |
| 2 | Implement sheds or houses | 2,000 | ..... | | | | |
| 1 | Machine shed | 2,500 | ..... | | | | |
| 2 | Office buildings | 665 | ..... | | | | |
| 1 | Printing office | 349 | ..... | | | | |
| 1 | Produce house | 21,525 | ..... | | | | |
| 1 | Public library | 100 | ..... | | | | |
| 1 | Pump house | 1,050 | ..... | | | | |

Average yearly loss, 167 structures, valued at $366,045.

# NOTES, ABSTRACTS, AND REVIEWS.

## DAILY WEATHER BULLETINS TRANSMITTED BY RADIO FROM THE UNITED STATES TO FRANCE.[1]

By E. B. CALVERT, Chief of Forecast Division.

[Weather Bureau, Washington, Sept. 27, 1923.]

The United States Weather Bureau sends each evening, Sundays and holidays included, to the French Meteorological Service at Paris, a bulletin containing observations taken at a number of stations in the United States, Alaska, and Canada, the position at the same hour of dominating high and low pressure areas, and weather reports from a limited number of ships in the North Atlantic Ocean. All land observations are of hour 0100 G. M. T., and Alaskan reports of hour 2100 G. M. T., current date. The bulletin is addressed to "Angot, Paris," and is forwarded through the United States naval radio station at Annapolis (NSS) to the radio station at Lyons (YN). The transmissions are made on a wave length of 17,145 meters, C. W., as the first message in the Annapolis schedule with France. This schedule begins at 0530 G. M. T., and transmission commences as soon thereafter as communication with Lyons (YN) can be established.

The messages are coded in a modified form of the International Meteorological Code, except that a date word is used to show the day of the month and the period of the day (a. m. or p. m.) that the land observations were taken, and key letters instead of numerals to desig-

[1] Reprinted from U. S. Hydrographic Bulletin No. 1776.

nate such places. The date word immediately follows the address (for date words see page 9, United States Weather Bureau Radiographic Code for vessel weather observers).

The arrangement of the messages are in coded groups, as follows:

*Land stations.*—Index letters, BBBDF.
*Ship reports.*—Ship call letters, JQLLL, IIIGG, BBBDF, TTC.
*Center of predominating high and low.*—Name of station, BBBDF.

MEANING OF SYMBOLS.

BBB=pressure reduced to sea level, in inches (initial figure, 2 or 3, omitted).
D=wind direction on scale 0 to 8, in which 0=calm, 1=N., 2=NE., 3=E., 4=SE., 5=S., 6=SW., 7=W., and 8=NW.
F=wind force in Beaufort scale.
J=day of week, numbered 1 to 7, beginning with Sunday.
Q=quarter of globe in which ship is situated (always in north latitude represented by figure 1, for ship reports included in Angot message).
LLL=latitude in degrees and minutes. The actual minutes are determined by multiplying the third coded figure by 6.
III=longitude in degrees and minutes. Minutes are determined in same manner as for latitude.
TT=temperature in Fahrenheit to nearest even degree.
C=state of sky according to scale, in which 1=clear (three-tenths clouds or less), 2=partly cloudy (four to seven-tenths), 3=cloudy (eight to ten-tenths), 4=raining, 5=snowing, 6=thunderstorms, 7=sleeting, 8=dense fog.

EXAMPLE OF BULLETIN.

Following is an example of a bulletin:

| | | |
|---|---|---|
| (Address) | ANGOT, PARIS. | |
| (Date word) | HOODOO. | |
| (St. Johns, N. F.) | J | 02652 |
| (Sydney, N. S.) | S | 01264 |
| (Father Point, Can.) | FP | 98662 |
| (Parry Sound, Can.) | PN | 00000 |
| (White River, Can.) | WR | 99800 |
| (Winnipeg, Can.) | WI | 99641 |
| (La Pas, Can.) | LP | 97861 |
| (Edmonton, Can.) | ED | 97081 |
| (Nantucket) | T | 00062 |
| (Washington) | WA | 00271 |
| (Hatteras) | H | 00263 |
| (Charleston) | C | 00471 |
| (Bermuda) | B | 02852 |
| (Key West) | K | 00231 |
| (Little Rock) | LR | 00431 |
| (Nashville) | NV | 01081 |
| (Cleveland) | V | 00441 |
| (Chicago) | CH | 00431 |
| (Duluth) | DU | 99871 |
| (Huron) | HN | 00051 |
| (Salt Lake City) | SLC | 97683 |
| (Helena) | HL | 98261 |
| (Denver) | DV | 99211 |
| (Roseburg) | RO | 98481 |
| (Tatoosh Island) | TAT | 99453 |
| (San Francisco) | SF | 99073 |
| (San Diego) | DI | 98681 |
| (Fort Worth) | FW | 99411 |
| (El Paso) | EP | 98431 |
| (Juneau, Alaska) | JU | 99651 |
| (Tanana, Alaska) | TN | 98281 |
| (Dutch Harbor, Alaska) | DH | 98200 |

| | | | | |
|---|---|---|---|---|
| KMI | 41389 | 73819 | 00021 | 723 |
| KDE | 41392 | 74119 | 98800 | 703 |
| ZTR | 41386 | 74219 | 00400 | 723 |
| KEGM | 41392 | 74219 | 00451 | 703 |
| (High) | BERMUDA | | 02852 | |
| (Low) | FATHER | | 98662 | |

NOTE.—Words in parenthesis are not transmitted.

The following partial translation will serve to illustrate how the messages are decoded:

HOODOO=29th day of the month, p. m. report.
J 02652: J=St. Johns, N. S.; 02652=(026) sea-level barometer pressure 30.26 inches, (5) winds from S., (2) wind force of 2 in Beaufort scale.

KMI 41389 73819 00021 723: KMI=steamship *Tivives;* 41389=(4) Wednesday, (1) north, (589) latitude 38° 54′; 73819=(738) longitude 75° 48′, (19) time of observation 1900 G. M. T.; 00021=(000) sea-level barometer reading 30.00 inches, (2) wind direction NE., (1) wind force 1 in Beaufort scale; 723=(72) temperature 72° F., (3) state of sky, cloudy.
BERMUDA 02852: Bermuda=Bermuda Islands, the location of nearest reporting station to center of predominating high; 02852=(028) barometer reading 30.28 inches, center of high, (5) wind direction, (2) wind force of 2 in Beaufort scale.
FATHER 98662: Father=Father Point, N. S., the location of nearest reporting station to center of predominating low; 98662=(986) barometer reading nearest center of low, 29.06 inches, (6) wind direction SW., and (2) wind force of 2 in Beaufort scale.

Each evening during a period of more than 25 years the United States Weather Bureau has been furnishing the French Meteorological Service with a bulletin showing current weather from a few stations. The messages formerly were sent by cable. The address "Angot" was utilized because Dr. A. Angot was director of the service. The address was perpetuated in honor of that distinguished meteorologist, who retired several years ago. The bulletin in its present expanded form began in July, 1922, and was the result of arrangements made during a visit to the United States Weather Bureau by Capt. Phillippe Wehrle, Assistant Director of the French Meteorological Service, and Prof. Marcel Coyecque, meteorologist of the French training ship *Jacques Cartier.* These arrangements provide for a daily exchange by radio of European and American meteorological reports, and were made possible by the cooperation of the Office of Communication of the French and American Navy Departments.

The American reports are broadcast from the Eiffel Tower (FL) radio station for the benefit of other European meteorological services and ships in western European waters. The broadcasts from Eiffel Tower are the same in form in which the bulletins are transmitted from the United States and follow immediately after the regular European weather report bulletins, which are transmitted at 11.30 G. M. T., on 2,600 meters, spark, and, in case of a breakdown of the spark apparatus, on 6,500 meters, C. W.

Although the "Angot" bulletins are specially addressed to the French Meteorological Service, they are intended for the general benefit, and shipmasters are at liberty to pick them up during trasnmission from Annapolis to Lyons and to use the information contained therein.

The bulletins containing European reports that were sent by radio to the United States Weather Bureau in exchange have been interrupted for several months. Consequently the time of their transmission and the wave length used is not available for publication herein. An announcement giving the details of this bulletin will be made as soon as the messages are resumed.

## WEATHER REPORTS IN SOUTH PACIFIC BY RADIO.

A wireless service for furnishing weather reports to vessels in the South Pacific waters and for studying the course of storms traversing the waters adjacent to the Pacific Islands has been inaugurated by the Navy Department of the New Zealand Government. The attention of all masters of ships is drawn to the importance of their cooperating with the department in reporting at intervals the weather conditions experienced in southern waters, particularly when low barometer readings would indicate the approach of hurricanes, typhoons, etc. It will hereafter be possible for vessels, by intercepting the routine broadcasted reports from New Zealand or Aus-

tralian stations, to ascertain the weather conditions at any place in the waters surrounding the Pacific Islands, New Zealand, and Auatralia.

Primarily this service is given for the benefit of the vessels in these waters, but it is hoped that from the information reported daily to the meteorological stations in New Zealand valuable information and data may be compiled to assist in forecasting weather conditions throughout the South Pacific waters.—*Vice Consul John E. Moran, Wellington, New Zealand.*

## SUBMARINE VOLCANO IN THE TONGA GROUP.

ANDREW THOMSON, Acting Director.

[Apia Observatory, Apia, Samoa, July 20, 1923.]

A submarine volcano was sighted on July 1 (eastern time) by Captain Davey, of the Union S. S. passenger liner *Tofua*, about 25 miles east of Tonga Tabu, the main island of the Tonga group.

The geographical position of the volcano was very closely 175° 33′ W., 20° 52′ S. When first sighted, the vapor from the volcano was taken to be the smoke of a passing steamer, but on nearer approach the density and great volume of steam made the true cause evident. The steam column rose to a height of 80 or 90 feet and trailed out like a banner over the ocean for a mile before becoming dissipated. At the level of the ocean the steam column was of the order of 100 feet in diameter. During the time the steam column was visible it remained fixed in size and position. There was marked turbulence and discoloration of the water at the point where the steam issued from the water. It was variously estimated that the water was shot up to a height from 2 to 4 feet above the sea.

The steam column was at the north end of a circular, pale-green area, about one-half mile in diameter. This area was sharply distinguished from the deep blue of the surrounding ocean. The charts give a depth of 550 fathoms for this locality. The volcano is well south of the position indicated on the charts for a volcano active in 1911, and is on the run of steamers from Suva to Nukualofa, the chief port of the Tonga group. There was no indication of volcanic activity when Captain Davey sailed over this position in 1920.

## GROUND SURFACE TEMPERATURES AS DEPENDENT ON INSOLATION AND AS CONTROLLING DIURNAL TEMPERATURE UNREST AND GUSTINESS.[1]

By M. ROBITZCH.

[Abstracted from Beitrage zur Physik der freien Atmosphäre, 1921, 9: 1-11.]

From March to June, 1916, continuous observations of the difference in temperature between the surface and a depth of 1.25 m. were made with thermo-elements and a recording galvanometer, in sandy soil without vegetation. Simultaneous records of insolation were also obtained. The closeness of the relation between ground surface temperature and the insolation on a horizontal surface on a day with cumulus clouds is evident from Figure 1. For the general discussion the author chose six bright days in May and June and averaged the values. Figure 2 shows the intensity of insolation normal to the sun's rays and on a horizontal surface. The occurrence at 10 a. m. of the maximum intensity at normal incidence is readily explained as a result of the effect of cumulus clouds in cutting off sunlight intermittently during the following six hours. The diurnal course of insolation on

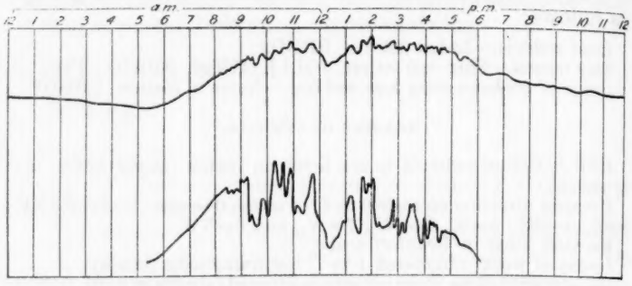


FIG. 1.—Relation between ground surface temperature (upper curve) and insolation on a horizontal surface (lower curve) on a day with cumulus clouds.

the horizontal surface of the ground, and the resulting surface temperature are shown in Figure 3, in which the ordinates have been so adjusted as to make the two curves

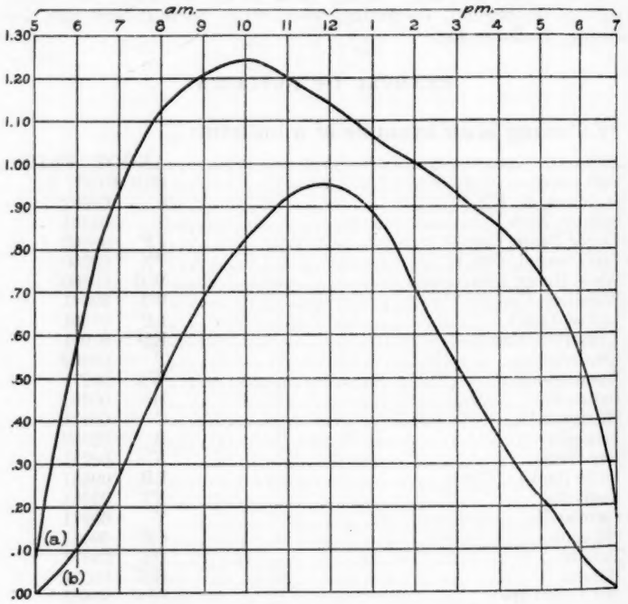


FIG. 2.—Intensity of insolation on a surface normal to the sun's rays (curve *a*) and on a horizontal surface (curve *b*).

cross at the minimum and maximum temperature, where insolation and outgoing radiation are equal. Thus the area ABCD equals CEAF, the former representing the

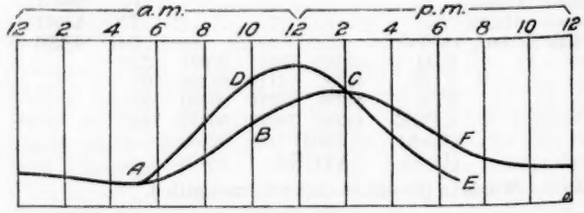


FIG. 3.—Diurnal course of insolation on a horizontal surface (curve *A D C E*) and resulting surface temperature (curve *A B C F*).

heat used in evaporating moisture from the ground and in warming the air, and the latter, the heat received by condensation and by return of heat from the air.

[1] Einige Bezelhungen zwischen der Temperature der Erdoberflache, der Insolation und anderen meteorologischen Faktoren.

As different surfaces of the ground heat very irregularly under strong insolation, in consequence of their diverse absorption and radiation coefficients, colors, characters of surface, specific heats, wetness, and conductivity, the immediately overlying air is correspondingly unevenly heated, the greatest differences being found with the most intense insolation. The movement of the air carries these irregularly heated masses past the thermometer, which records temperature unrest. Figure 4 shows the closeness with which this unrest corresponds to the intensity of insolation. The flattenings of the curve of temperature unrest just after

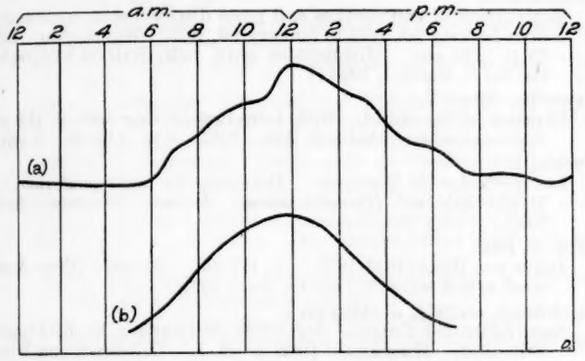


FIG. 4.—Curve of temperature unrest (*a*) and insolation (*b*).

10 a. m. and 5 p. m. correspond to the times of beginning and ending of active convection, which, thus, is seen to play a secondary rôle.

Gustiness of the ground wind depends directly on convection, which in turn is a function of the heating of the lower air by the ground. Thus it is not surprising to find the close relationship between gustiness and ground surface temperature shown in Figure 5. The minor irregularities in the gustiness as curve between about 8 a. m. and 2–3 p. m. have their approximate counterparts in the curve of temperature unrest. (Fig. 4.)

At the close of the paper, attention is directed to similarities sometimes found between depressions in the

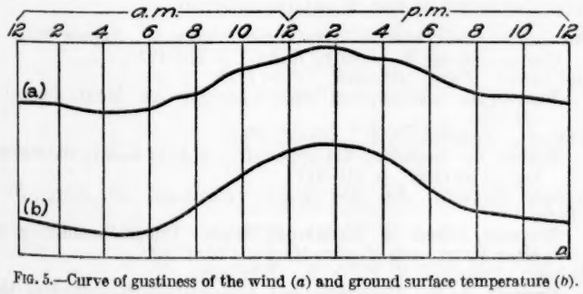


FIG. 5.—Curve of gustiness of the wind (*a*) and ground surface temperature (*b*).

rising and falling curves of the actionmeter on the same day. That is, depressions occur with the same angular height of the sun. These the author explains as the result of increased absorption or reflection at the top of an inversion layer. On March 12, 1919, there was an inversion of about 6° C. reaching to 300 m. and one of 1° C. at about 2,400 m.—*C. F. B.*

## UPPER-AIR OBSERVATIONS IN NORTH RUSSIA.

[Reprinted from *Nature* (London), Aug. 18, 1923, p. 248.]

A Professional Note, volume 3, No. 32, carried out by Mr. W. H. Pick, has been published on the above by the Meteorological Office, Air Ministry. The observations are based upon pilot-balloon ascents between February 25 and September 13, 1919, at three stations in northwest Russia. The stations are Murmansk, at the head of the Kola Creek, in latitude about 69° N., Archangel on the southwestern coast of the White Sea, in latitude 64° 33′ N., and Lumbushi on the Murman Railway, in latitude about 68° N. The ascents were all carried out with one theodolite only, the balloon being given a vertical lift of, theoretically, 500 feet per minute. The high latitude in which the observations were obtained renders them of value. There were at Murmansk 57 occasions on which the surface winds was in the north east wuadrant, and on 10 of these, that is, 17.5 per cent of the total, the wind backed continuously up to 2,000 feet. On the other hand, there were 164 occasions on which the surface wind was not in the northeast quadrant, and in only 5 of these; that is, 3 per cent of the whole, did the wind back continuously upward. At Murmansk three ascents reached to a height of 40,000 feet, where two of the winds were northwest and one southwest. Two ascents reached to 60,000 feet, where both winds were southwest. Seven ascents reached 20,000 feet, at that height four of the winds were southwest and two northwest. Of the ascents carried out at Archangel only one reached 20,000 feet, where the wind was southerly. Of the ascents at Lumbushi, six attained a height of 20,000 feet, giving two northwesterly winds, three northeasterly, and one southerly.

## WHY ARE TYPHOONS IN CHINA SEA MORE FREQUENT THAN WEST INDIAN HURRICANES?

A correspondent of the Weather Bureau raises the above question. The reply by the Chief of Weather Bureau will doubtless be of interest to REVIEW readers and is accordingly reproduced below:

It is a definitely known fact that tropical cyclones have their origin within the region of calms of the Tropics, commonly known as the doldrums, and that cyclones form in this belt of calms only when it lies at an appreciable distance from the Equator. Now if nothing more than still, or relatively still, moist, warm air were essential to the formation of a cylcone of the Tropics then one would expect to find several in operation at the same time when this belt of calms lies say ten or more degrees either north or south of the Equator. But this does not follow, for it is our experience that the major part of a cyclone season may pass without the semblance of a hurricane, and rarely, if ever, do we note more than one cyclone at any one time in the West Indies. The foregoing being accepted as true, we must then seek a contributory cause of the formation of a cyclone outside the still, moist, warm air of the doldrums. Now, if we consider the seeming fact that the loci of tropical cyclonic formations on the North Atlantic are two in number, one the Western Caribbean Sea and the other the region about the Cape Verde Islands, where the belt of calms is at times flanked by oppositely directed systems of winds, one of which is the northeast trade of our hemisphere and the other the similar trade wind of the southern hemisphere, which after having crossed the Equator comes under the right-hand deflective influence of the earth's rotation, and is changed to a southwest wind system, it is reasonable to assume that these passing wind systems have perhaps much to do with the formation of tropical cyclones. Over the North Atlantic, within the Tropics, it is probably true that this contributory cause is rarely in operation, whereas in the East Indies the southwest monsoon blows during much of the cyclone season and on approaching, but passing to the south of the northeast trade wind system of the North Pacific Ocean, there naturally arise many occasions when the conditions are what may be regarded as ideal for the development of cyclones. Hence the greater frequency of the typhoon. Of course the deflective influence of the earth's rotation plays an important part in the changing of the course of these two primary wind systems (each one being turned to the right), and by doing so lowers the barometric pressure over the intervening region and in addition thereto determines the direction of rotation of the winds of the cyclone itself. Now, if these primary wind systems initiate an incipient whirl, then the condensation of water vapor, and the consequent setting free of latent heat, immediately gives the energy that maintains the cyclone during days and at times weeks. Otherwise, it seems likely the life of the cyclone would be very short.

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C. F. TALMAN, Meteorologist in Charge of Library.

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## SOLAR OBSERVATIONS.

### SOLAR AND SKY RADIATION MEASUREMENTS DURING AUGUST, 1923.

By IRVING F. HAND, Acting in Charge, Solar Radiation Investigations.

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for April, 1920, **48**:225, and a note in the REVIEW for November, 1922, **50**:595.

From Table 1 it is seen that direct solar radiation intensities averaged below the normal values for August at Washington, D. C., and above normal at Madison, Wis., and Lincoln, Nebr. A noon intensity of 1.46 gram-calories per minute per square centimeter measured on the 24th at Madison, Wis., is the highest ever measured at that station in August.

Table 2 shows deficiencies in the radiation received from the sun and sky at all three stations, the deficiency being especially marked during the first week at Washington.

Skylight polarization measurements obtained at Washington on 11 days give a mean of 47 per cent with a maximum of 58 per cent on the 14th, At Madison measurements on 7 days give a mean of 66 per cent with a maximum of 74 per cent on the 19th. These are below average values for August at Washington, but decidedly above normal at Madison. In fact, the value obtained on the 19th is the highest ever obtained at Madison in August.

TABLE 1.—*Solar radiation intensities during August, 1923.*

[Gram-calories per minute per square centimeter of normal surface.]

**Washington, D. C.**

| Date. | Sun's zenith distance. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8 a.m. | 78.7° | 75.7° | 70.7° | 60.0° | 0.0° | 60.0° | 70.7° | 75.7° | 78.7° | Noon. |
| | 75th mer. time. | Air mass. | | | | | | | | | Local mean solar time. |
| | | A. M. | | | | | P. M. | | | | |
| | e. | 5.0 | 4.0 | 3.0 | 2.0 | *1.0 | 2.0 | 3.0 | 4.0 | 5.0 | e. |
| | *mm.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *mm.* |
| Aug. 13 | 15.65 | 0.55 | 0.68 | 0.83 | 1.07 | 1.19 | 0.71 | ..... | ..... | ..... | 11.38 |
| 14 | 10.21 | 0.61 | 0.71 | 0.83 | 0.99 | 1.27 | 0.98 | ..... | ..... | ..... | 12.68 |
| 15 | 17.37 | ..... | ..... | ..... | 0.63 | 1.19 | ..... | ..... | ..... | ..... | 11.38 |
| 16 | 11.81 | ..... | ..... | ..... | ..... | 0.90 | ..... | ..... | ..... | ..... | 12.68 |
| 20 | 13.61 | ..... | ..... | ..... | ..... | 1.09 | 0.98 | ..... | ..... | ..... | 11.81 |
| 21 | 16.20 | ..... | ..... | ..... | ..... | 1.20 | ..... | ..... | ..... | ..... | 17.96 |
| 22 | 9.47 | ..... | ..... | ..... | ..... | ..... | 1.20 | ..... | ..... | ..... | 8.18 |
| 24 | 10.97 | ..... | ..... | ..... | ..... | 1.06 | ..... | ..... | ..... | ..... | 7.87 |
| 25 | 12.68 | ..... | ..... | ..... | 0.98 | 1.32 | ..... | ..... | ..... | ..... | 9.47 |
| 30 | 13.61 | ..... | 0.40 | 0.55 | 0.81 | 1.00 | ..... | ..... | ..... | ..... | 16.20 |
| 31 | 15.11 | ..... | ..... | ..... | 0.55 | 0.82 | ..... | ..... | ..... | ..... | 12.68 |
| Means | ..... | (0.58) | **0.60** | **0.74** | **0.84** | **1.10** | **0.97** | ..... | ..... | ..... | ..... |
| Departures | ..... | **−0.04** | **−0.04** | **−0.01** | **−0.07** | **−0.12** | **−0.02** | ..... | ..... | ..... | ..... |

* Extrapolated.

TABLE 1.—*Solar radiation intensities during August, 1923*—Continued.

**Madison, Wis.**

| Date. | Sun's zenith distance. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8 a.m. | 18.7° | 75.7° | 70.7° | 60.0° | 0.0° | 60.0° | 70.0° | 75.7° | 18.7° | Noon. |
| | 75th mer. time. | Air mass. | | | | | | | | | Local mean solar time. |
| | | A. M. | | | | | P. M. | | | | |
| | e. | 5.0 | 4.0 | 3.0 | 2.0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | e. |
| | *mm.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *mm.* |
| Aug. 17 | 10.59 | ..... | ..... | ..... | 1.00 | 1.28 | ..... | ..... | ..... | ..... | 10.97 |
| 18 | 10.97 | ..... | ..... | ..... | ..... | 1.30 | ..... | ..... | ..... | ..... | 11.81 |
| 19 | 10.97 | ..... | ..... | ..... | 1.22 | 1.40 | ..... | ..... | ..... | ..... | 10.21 |
| 22 | 7.04 | ..... | ..... | ..... | 1.20 | ..... | ..... | ..... | ..... | ..... | 7.29 |
| 23 | 7.87 | ..... | ..... | 0.90 | 1.13 | 1.41 | 1.13 | ..... | ..... | ..... | 6.50 |
| 24 | 7.29 | ..... | ..... | 1.09 | 1.31 | 1.49 | 1.30 | ..... | ..... | ..... | 10.59 |
| 29 | 9.14 | ..... | ..... | ..... | 1.06 | ..... | ..... | ..... | ..... | ..... | 10.59 |
| 30 | 12.68 | ..... | ..... | ..... | ..... | 1.40 | ..... | ..... | ..... | ..... | 14.60 |
| Means | ..... | ..... | ..... | (1.00) | **1.15** | **1.38** | (1.22) | ..... | ..... | ..... | ..... |
| Departures | ..... | ..... | ..... | **+0.07** | **+0.06** | **+0.07** | **+0.18** | ..... | ..... | ..... | ..... |

**Lincoln, Nebr.**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 10 | 17.37 | ..... | ..... | ..... | ..... | ..... | 1.01 | 0.91 | 0.79 | 0.69 | 18.59 |
| 11 | 15.65 | ..... | 0.80 | 0.97 | 1.16 | 1.35 | ..... | ..... | ..... | ..... | 17.37 |
| 12 | 14.10 | ..... | ..... | ..... | ..... | ..... | ..... | 1.01 | 0.88 | ..... | 13.13 |
| 13 | 14.88 | ..... | ..... | 1.02 | 1.21 | 1.45 | 1.13 | 0.93 | 0.79 | 0.69 | 14.10 |
| 14 | 17.37 | ..... | 0.83 | 0.92 | 1.13 | 1.27 | ..... | ..... | ..... | ..... | 20.57 |
| 22 | 7.04 | ..... | 0.93 | 1.05 | 1.22 | ..... | ..... | ..... | ..... | ..... | 7.29 |
| 24 | 9.14 | ..... | 0.74 | 1.01 | ..... | ..... | ..... | ..... | ..... | ..... | 8.48 |
| 25 | 1.38 | ..... | ..... | ..... | ..... | ..... | 1.02 | ..... | ..... | ..... | 13.13 |
| Means | ..... | ..... | **0.82** | **0.99** | **1.18** | **1.36** | **1.05** | **0.95** | **0.82** | (0.69) | ..... |
| Departures | ..... | ..... | **+0.03** | **+0.09** | **+0.10** | **+0.08** | **−0.03** | **+0.06** | **+0.06** | **−0.02** | ..... |

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

| Week beginning. | Average daily radiation. | | | Average daily departure for the week. | | | Excess or deficiency since first of year. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Washington. | Madison. | Lincoln. | Washington. | Madison. | Lincoln. | Washington. | Madison. | Lincoln. |
| | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* |
| July 30 | 279 | 438 | 462 | −188 | −34 | −73 | −3,360 | +676 | −1,235 |
| Aug. 6 | 395 | 420 | 388 | −61 | −36 | −128 | −3,788 | +424 | −2,128 |
| 13 | 451 | 492 | 489 | +13 | +51 | −4 | −3,694 | +780 | −1,158 |
| 20 | 487 | 427 | 530 | +69 | +4 | +55 | −3,213 | +811 | −1,773 |
| 27 | 406 | 291 | 439 | −1 | −111 | −19 | −3,223 | +34 | −1,907 |

# WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

## NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month as determined at different land stations on the coast and islands of the North Atlantic Ocean did not differ materially from the normal. The following figures show the average pressure at 8 a. m., 75th meridian time, with approximate departures, at a number of selected stations. The barometer readings are in inches, and the normals were taken from the Pilot Chart.

St. Johns, Newfoundland, average 29.90, departure −0.08. Nantucket, 29.99, ±0.00. Hatteras, 30.01, −0.03. Key West, 30.05, +0.07. New Orleans, 30.03, +0.07. Swan Island, 29.92, ±0.00. Turks Island, 30.10, +0.10. Bermuda, 30.15, +0.06. Horta, Azores, 30.20, −0.01. Lerwick, Shetland Islands, 29.70, −0.10. Valentia, Ireland, 29.91, −0.02. London, 29.95, −0.04.

The number of days on which winds of gale force were reported was considerably greater than usual over the eastern section of the steamer lanes. They were recorded on from 5 to 7 days in the four 5-degree squares between the 45th and 50th parallels, north latitude, and the 5th and 25th meridians, west longitude, and on 4 days in each of the three squares immediately to the eastward. In marked contrast to these conditions were those that prevailed over the region west of the 55th meridian, where gales were not reported on more than one day in any 5-degree square, while south of the 35th parallel moderate weather apparantly prevailed during the entire month, with exception of the disturbance of the 24th and 25th in the Caribbean Sea that will be referred to later.

Taking the ocean as a whole, fog was not as prevalent as in July, although in the vicinity of Nantucket it was observed on 20 days, and on 10 days in the square between latitudes 45° and 50° N., longitude, 10° and 15° W. Over the remainder of the steamer lanes and off the coast of northern Europe the number of days on which fog was recorded was not far from the normal.

The month began with a moderate depression over the region between the 25th meridian and the European coast that afterwards developed into one of the most severe disturbances of the month, as shown by Charts VIII to XI for the period from the 2d to 5th, inclusive.

On the 2d the depression in the vicinity of Ireland resulted in exceptionally heavy winds over a limited area, while moderate weather prevailed over the remainder of the ocean. Storm log:

British S. S. *Sutton Hall:*

Gale began on the 2d, wind SSW. Lowest barometer 29.40 inches at 8 a. m. on the 2d, wind SSW., 9, in latitude 52° 6′ N., longitude 5° 54′ W. End of gale on the 3d, wind WSW. Highest force of wind 9, SSW; shifts SSW.–W.

On the 3d there appeared a well-developed LOW central near latitude 47° N., longitude 30° W., that moved slowly eastward accompanied by strong gales. Storm logs:

British S. S. *Bolivian:*

Gale began on the 3d, wind SE. Lowest barometer 29.24 inches on the 3d, wind WSW., 11, in latitude 47° 30′ N., longitude 27° 50′ W. End at 4 p. m. on the 4th. Highest force of wind 11. Shifts SW.–W.–WNW.

British S. S. *Asian:*

Gale began on the 3d, wind ESE. Lowest barometer 29.53 inches at 7 p. m. on the 4th, wind SSW., 8, in latitude 50° 27′ N., longitude 18° 47′ W. End on the 5th, wind WNW. Highest force of wind, 9; shifts, S.–SSW.–SW.

On the 3d the American tank steamer *Chester Sun* observed a waterspout in the Gulf of Mexico, as shown by following report.

August 3, about 5:35 a. m., in latitude 28° 34′ N., longitude 91° 35′ W., large waterspout and one smaller formed in the middle of a large nimbus cloud. Both parted in the center and disappeared as the breeze moved the cloud along.

From the 6th to the 13th, taking the ocean as a whole, the atmospheric conditions were comparatively sluggish, although during this period one or two moderate disturbances were indicated by reports received.

On the 7th the second waterspout of the season visited the Gulf of Mexico, as seen in following report from American S. S. *Hadnot.*

At 2:30 p. m. on the 7th, in latitude 23° 33′ N., longitude 88° 36′ W., observed a large waterspout about 6 miles to the northwestward and moving in that direction, followed by a heavy rain squall. Wind E. by N., force 3. Barometer 30.07 inches. Sea moderate. Temperature of air 83° F.; wet bulb 81° F.; sea water 84° F. Observer, C. De Stefano, 2d officer.

On the 14th Newfoundland was surrounded by a fairly well developed area of low pressure with winds of moderate gale force in the southerly and southeasterly quadrants; this LOW moved rapidly eastward and on the 15th the center was near latitude 47° N., longitude 40° W. Storm log:

American S. S. *Eastern Star:*

Gale began on the 14th, wind S. Lowest barometer 29.99 inches at 2 p. m. on the 14th, wind S., 7, in latitude 44° 16′ N., longitude 40° 30′ W. End on the 15th, wind W. Highest force of wind 9, S.; shifts S.–SSW.–SW.

From the 16th to the 18th comparatively high pressure was the rule over the greater part of the ocean, although a depression accompanied by moderate winds surrounded the greater part of England; this moved slowly eastward, and on the 18th was off the Scandinavian coast. On the 19th a disturbance was central near latitude 40° N., longitude 45° W., and moderate gales were reported over the area between that point and the Bermudas. Storm log:

Italian S. S. *Milazzo:*

Gale began on the 18th, wind SW. Lowest barometer 30 inches at 8 a. m. on the 18th, wind SW., 7, in latitude 36° 01′ N., longitude 56° 43′ W. End on the 21st, wind W.; highest force of wind 8. At 8 a. m. on the 20th wind shifted from SW. to W.

By the 20th the center had reached a point near latitude 50° N., longitude 20° W., and on the 21st was off the east coast of Scotland. There appeared on the 22d two unusually deep depressions; the first over the Gulf of St. Lawrence and the second near the north coast of Scotland. The 8 a. m. 75th meridian time, barometric readings at Fathers Point, Quebec, and Lerwick, Shetland Islands, were 29.04 inches and 28.88 inches, respectively. A few vessels in the vicinity of the western LOW, as well as in mid-ocean, rendered storm logs, while according to reports received, moderate weather prevailed along the greater part of the European coast. On the 23d the conditions were similar to those of the previous day, although both of the low areas had begun to fill in. Storm logs:

British S. S. *Kenbane Head:*

Gale began on the 22d, wind NW. Lowest barometer 28.83 inches at 11 a. m. on the 22d, wind NW., in latitude 48° 50′ N., longitude 62° 40′ W. End on the 23d, wind W. Highest force of wind 9, WNW.; shifts S.–NW.

British S. S. *Wells City:*

Gale began on the 22d, wind S. Lowest barometer 28.67 inches at 2 a. m. on the 23d, wind W., 8 in latitude 50° 18′ N., longitude 25° 45′ W. End on the 23d, wind NNW. Highest force of wind 9; shifts SW.–W.–NW.

On the 24th a disturbance appeared central near latitude 53° N., longitude 32 W.; it drifted slowly eastward, apparently gaining slightly in intensity and on the 27th was between the 20th meridian and the European coast. Storm log:

British S. S. *Canadian Leader:*

Gale began on the 23d, wind S. Lowest barometer 29.49 inches at 4 p. m. on the 24th, wind WSW., 7, in latitude 53° 48′ N., longitude 31° 26′ W. End on the 28th, wind WNW. Highest force of wind 9, WNW.; shifts SW.–WNW.

From the 24th to 26th one vessel encountered winds of gale force in the Caribbean Sea. Unfortunately this was the only report received from craft in that locality, and it is therefore difficult to determine accurately the nature and extent of this gale. Storm log:

American S. S. *Winnebago*—

Gale began on the 24th, wind NE. Lowest barometer 29.81 inches at 6 p. m. on the 24th, wind NE., in latitude 11° N., longitude 78° 55′ W. End on the 26th, wind ENE., 8; steady from ENE. and NE.

On the 28th the third waterspout of the month was encountered in the Gulf of Mexico, as shown by the following report:

In latitude 27° 55′ N., longitude 87° 40′ W., observed a large waterspout about 5 miles to the northeastward and moving north. Wind SE., force 2. Barometer 30.11 inches. Sea smooth. Temperature of the air 85° F., water 84° F. American S. S. *Hadnot*, Capt. P. Gibson, Chief Officer V. H. Casey.

On the 28th still another area of low pressure appeared over the eastern section of the ocean, central near latitude 48° N., longitude 25° W.; on the 29th it was near the southern shore of Ireland, and heavy gales prevailed over the region between the 15th meridian and the European coast. Storm logs:

British S. S. *Saxonia:*

Gale began on the 28th, wind NW. Lowest barometer 29.36 inches at 8:25 p. m. on the 28th, wind N.,12, in latitude 48° 51′ N., longitude 19° 11′ W. End on the 29th, wind N. Highest force of wind 12, N. Between 8 and 8:25 p. m. on the 28th, wind fell to moderate breeze and veered to westerly from WSW. At 8.25 p. m. wind veered to NW., in a hurricane squall. At 8:33 wind veered to N. and blew with hurricane force until 9.40 p. m., when it eased to force 9.

American S. S. *Westerner:*

Gale began on the 28th, wind S. Lowest barometer 29.28 inches at 11 p. m. on the 28th, wind S., 7, in latitude 48° 08′ N., longitude 11° 52′ W. End on the 29th, wind NW. Highest force of wind 12, NW.; shifts WSW.–W.

American S. S. *Effna:*

Gale began on the 27th, wind WNW. Lowest barometer 29.64 inches at 4 a. m. on the 29th, wind WSW., 8, in latitude 46° 35′ N., longitude 12 W. End on the 29th, wind NNW. Highest force of wind 10, NNW.; shifts SSW.–WSW.–NW.

This disturbance moved rapidly northeastward and on the 30th was apparently over the North Sea, although, as during the last two days of the month no reports were received from vessels in these waters, it was necessary to depend on observations from adjacent land stations in order to determine approximately its position and character.

## NORTH PACIFIC OCEAN.

By WILLIS E. HURD.

The greater part of the North Pacific Ocean was comparatively quiescent during August, and aside from the tropical storms of the Far East and one hurricane to the westward of the Hawaiian Islands, few disturbances of consequence were reported to have occurred.

Over the eastern part of the ocean pressure for the month was close to the normal. At Dutch Harbor the average of the p. m. observations (29 days) was 29.85 inches as compared with the normal of 29.88. This represented a net decline in pressure from that of the preceding month of July of 0.31 inch. The highest reading, 30.34 inch, was recorded on the 13th; the lowest, 29.32, on the 30th. At Midway Island the daily departures were unimportant, the absolute range for the month, considering p. m. observations only, being 0.16 inch. The highest reading was 30.12, on the 7th and 8th; the lowest 29.96, on the 23d. Average for the month 30.05 inches; normal, 30.06 inches. Pressure at Honolulu was also featureless, the absolute range there for the month being only 0.19 inch. The highest reading 30.06, occurred on the 25th; the lowest, 29.87, on the 18th. Average for the month, p. m. observations, 30.00 inches, normal, 29.99 inches.

Low pressure persisted throughout the month over some portion of the Aleutian area, but the conditions were those of summer, and no gale of force higher than 7 was reported. The only accession to the Aleutian LOW this month seems to have been a depression which originated about midway between Honolulu and San Francisco on the 13th. The depression deepened slightly on the 14th and moved slowly toward the Gulf of Alaska, emerging from the area usually occupied by the North Pacific HIGH about the 21st. It seems not to have been accompanied by gales.

The trades prevailed in the Hawaiian area, with winds generally from the east at Honolulu. The maximum velocity at this point was 30 miles, from the east, on the 28th. There was much cloudy weather, the percentage of sunshine being the lowest in the 19 years of record.

The one feature of unusual interest in the weather conditions over west longitudes was the intense tropical cyclone which occurred on the 20th to 22d of the month between Hawaii and Midway Island. The storm is discussed elsewhere in this issue of the REVIEW under the title of "A tropical storm west of Hawaii," by Mr. Thomas A. Blair. The only additional information concerning the disturbance is to be found in the following report submitted by Third Officer H. E. Wollaston of the American S. S. *President Lincoln*, Capt. Ryland Drennan, westward bound:

Latitude and longitude of beginning, 24° 20′ N., 163° 55′ W.
Latitude and longitude of lowest bar., 25° 05′ N., 165° 20′ W.
Latitude and longitude of end, 25° 50′ N., 167° 10′ W.

| Date and time. | Wind. | Barometer. | Air. | Sea. |
|---|---|---|---|---|
| Aug. 21: | | | | |
| 8:00 a. m. | SE. 7 | 29.96 | 79 | 77 |
| 9:00 a. m. | SE. 7 | 90 | 79 | 78 |
| 10:00 a. m. | SE. 7 | 85 | 79 | 78 |
| 11:00 a. m. | SE. 7–8 | 80 | 79 | 78 |
| 12:00 a. m. | SE. 8 | 75 | 79 | 78 |

8–12. Overcast, with heavy rain. Rough southeasterly sea and heavy swell.

| Date and time. | Wind. | Barometer. | Air. | Sea. |
|---|---|---|---|---|
| Aug. 21: | | | | |
| 1:00 p. m. | SE. 9 | 29.58 | 78 | 77 |
| 1:30 p. m. | SE. 10 | 42 | 77 | 76 |
| 2:00 p. m. | SE. 10 | 34 | 77 | 76 |
| 2:30 p. m. | ESE. 11 | 20 | 77 | 76 |
| 3:00 p. m. | E. 12 | 29.00 | 77 | 76 |
| 3:15 p. m. | ENE. 12 | 28.80 | 76 | 76 |
| 3:30 p. m. | NE. 12–4–12 | 85 | 76 | 76 |
| 4:00 p. m. | NE. 12 | 82 | 76 | |

12–4. Squally weather; wind, hurricane force, with frequent lulls. Heavy, continuous rain and mountainous seas throughout watch.

Sea and wind hauling to the north'ard all the time; 3:30 p. m. probably in center of hurricane, as wind died to moderate breeze for about 15 minutes, while mountainous seas were coming from all directions; 2:30 to 4 p. m. turned very dark.

| Date and time. | Wind. | Barometer. | Air. | Sea. |
|---|---|---|---|---|
| Aug. 21: | | | | |
| 4:30 p. m. | NE. 12 | 28.86 | 76 | 76 |
| 5:00 p. m. | NNE. 12 | 88 | 75 | 76 |
| 5.30 p. m. | NNE. 12 | 96 | 75 | 76 |
| 6:00 p. m. | NNE. 12 | 98 | 74 | 76 |

4–6. Squally, wind coming in puffs. Hurricane force dying to strong breeze for a few minutes at a time. Overcast, with heavy rain. Very dark, sky brightening up at times.

| Date and time. | Wind. | Barometer. | Air. | Sea. |
|---|---|---|---|---|
| Aug. 21: | | | | |
| 6:30 p. m. | N. by E. 12 | 29.24 | 74 | 76 |
| 7:00 p. m. | N. 12 | 32 | 73 | 75 |
| 7:30 p. m. | N. by W. 12 | 48 | 73 | 75 |
| 8:00 p. m. | N. by W. 12 | 58 | 72 | 74 |

Barometer going up in jumps. Oscillating considerably. Wind blowing steadily, hurricane force. Mountainous seas gradually moderating toward 8 o'clock. Overcast, with occasional clear spots appearing in sky. Continuous heavy rain.

| Date and time. | Wind. | Barometer. | Air. | Sea. |
|---|---|---|---|---|
| Aug. 21: | | | | |
| 9:00 p. m. | N. by W. 11 | 29.65 | 71 | 73 |
| 10:00 p. m. | N. by W. 10 | 70 | 71 | 73 |
| 11:00 p. m. | N. 9 | 80 | 72 | 73 |
| 12:00 p. m. | N. 9–7 | 80 | 72 | 73 |

8–12. Wind and sea moderating steadily. Rain stopped. Sky clearing in places. Rough northerly sea with heavy northeast swell.

| Date and time. | Wind. | Barometer. | Air. | Sea. |
|---|---|---|---|---|
| Aug. 22: | | | | |
| 1:00 a. m. | N. by E. 6 | 29.85 | 75 | 75 |
| 2:00 a. m. | N. by E. 5 | 86 | 76 | 75 |
| 3:00 a. m. | N. by E. 4 | 88 | 77 | 77 |

Rough northeasterly sea with long heavy swell. Overcast and cloudy to fine clear weather at 3 o'clock.

Toward the close of the month certain unsettled conditions off the lower west coast of Mexico leads to the belief that a tropical storm there was in some stage of development and that its activities ended in heavy rainfall. On the 27th and 28th easterly winds of force 8 occurred over the entrance and to the southward of the Gulf of Tehuantepec. These gales were reported by the American S. S. *Virginian* and the Norwegian S. S. *Ranenfjord*. Following this, the American S. S. *Thomas H. Wheeler*, Capt. L. S. McKenzie, southward bound, experienced continued east-southeasterly gales and heavy seas, and observed a slightly depressed barometer during the entire night of the 29th–30th. Near midnight the wind rose to force 9, lowest pressure 29.84 inches. Third officer B. A. Thompson, in his account of this disturbance, supposed the gale to have been one belonging to the "edge of a cyclone." The changing direction of the sea seemed also to confirm his supposition. To quote:

Our course during the storm was 116° true, and the seas were slightly on our port bow, though after midnight of the 29th a sea came over the starboard bow and carried away a large ventilator.

The local noon positions of this vessel were as follows: 29th, 18° 34′ N., 105° 09′ W.; 30th, 17° 34′ N., 102° 44′ W.

During the same night the American S. S. *Algonquin* experienced southeasterly to south-southeasterly winds, highest force 8, in and near latitude 19° 42′ N., longitude 106° 22′ W.

The American S. S. *Arizonan*, Capt. J. E. Tuttle, Los Angeles toward Balboa, was also involved. This vessel's lowest observed pressure was 29.82 inches, in 18° 55′ N., 105° 25′ W. Mr. A. Hamer, the second officer, thus reported:

August 30. Wind was hauling with a force of 10 from 12:30 a. m. to 2:45 a. m., ESE. to E. to SE. and at 4:00 a. m. settled down to East; at 5:00 a. m. shifted to SE. 10. 8:00 a. m. moderating, with wind SE. 8. 8:30 a. m. wind SE by S., force 7, barometer (corrected) 29.95. 9:00 a. m. SE. 6, barometer steady; heavy, driving rain squalls.

The following is quoted from the observer on board the American S. S. *E. L. Doheny III:*

August 31, 7 a. m. Ten miles south of Cape San Lucas had an exceptionally heavy rain squall which lasted for an hour. Rain is supposed to be almost unheard of on this coast. The wind was from the SE., force 4, barometer, 29.93 (corrected).

In the Far East pressure was low throughout August, and a number of depressions occurred, at least three of which developed into violent typhoons.

On the 1st of the month a depression appeared to the westward of Luzon. It crossed the China Sea on the 3d and 4th, and was felt as a cyclone of some energy along the lower China coast on the 4th to 6th. Capt. G. St. M. Stocker, of the pilot station on Double Island, Swatow, reported gales of maximum force 8 during a considerable part of the 5th, lowest pressure 29.40 inches. Several vessels experienced rough weather in the vicinity on the same date. The American S. S. *President Cleveland* was in Hongkong harbor during the storm, and with other vessels was warned to seek safety in the typhoon shelters. Second Officer Udley, the observer on board, reported a maximum wind force of 10 from the south-southwest, lowest pressure 28.88 inches. The British S. S. *Hyson*, Capt. A. S. Blues, Hongkong toward Manila, experienced squalls and heavy rain in the typhoon area; highest force of wind 8 from the southwest, lowest pressure, 29.33 inches, in latitude 21° 26′ N., longitude 114°53′ E. The Japanese S. S. *Altai Maru*, Capt. H. Chiba, Hongkong toward Moji, encountered the full force of the storm while near latitude 22° 45′ N., longitude 116° 50′ E.; wind ESE., 12; lowest pressure, 28.31 inches.

A second disturbance followed closely in the wake of this typhoon. It appeared as a depression to the westward of Guam about the 3d, and by the 5th seems to have acquired a considerable degree of development over and to the southward of the Bonin Islands. On the 7th the Dutch S. S. *Saleier*, Captain Vollewens, Shanghai toward Singapore, encountered the southwesterly winds of this storm, highest force 7, lowest pressure 29.16 inches, in 25° 57′ N., 120° 21′ E. The *Altai Maru*, that had weathered the previous gale, was also caught on the 7th in the northern edge of the second storm, though less severely, the highest wind force observed being E. 8, lowest pressure 29.10 inches, in 26° 37′ N., 119° 55′ E. Considerably farther to the southward, the American S. S. *Dilworth*, Capt. D. S. MacAlpine, Cebu toward San Francisco, was also engaged with the storm. Her lowest observed pressure was 29.12 inches, highest wind force 10 SW., in latitude 16° N., longitude 136° 56′ E. On the 9th the American S. S. *Stockton*, Capt. K. P. Olsen, Port San Luis toward Manila, was in 21° 51′ N., 129° 42′ E.,

or midway between the positions of the *Altai Maru* and the *Dilworth* on the 7th. At this point she experienced a southeast hurricane, lowest pressure 29.21 inches; heavy southeast to southwest sea and swell. The typhoon at 8 p. m. of the 9th was central slightly to the west-northwestward of Taiwan. No further reports of the storm are available at this writing.

The third typhoon of the month acted similarly to its predecessor. About August 11 it seems to have originated in the Marianas, moving thence west-northwestward until it struck Hongkong on the morning of the 18th. Here much damage was done to shipping and on shore, and there was a considerable loss of life. According to reports this typhoon is the worst experienced in Hongkong since 1906. Previous records of hurricane velocities and low pressures here are said to have been broken when the wind rose to 130 miles an hour, and the pressure fell to 28.66 inches. Among the marine casualties in the harbor were the British S. S. *Ming Sang* and the submarine *L-9*. The British S. S. *Mylie* was reported lost in the typhoon at sea on the 16th.

Fog was of frequent occurrence over the northern shipping routes, and was reported on 9 days outside of San Francisco Harbor. There were reports of fog on several days off the southern coast of Alaska, and in the Arctic Ocean between the 65th and 70th parallels.

## ONE DEPRESSION AND ONE TYPHOON IN THE PHILIPPINES DURING JULY, 1923.

By Rev. José Coronas, S. J.

[Weather Bureau, Manila, P. I.]

*Depression-typhoon of July 10 to 24.*—This depression appeared on the 15th to the south of Guam, probably not far from 145° longitude E. and 6° latitude N. It moved WNW. and NW. by W. until the 17th, when it began to move westward, thus traversing the Philippines on the 18th through the southeastern part of Luzon, Marinduque, and the northernmost part of Mindoro. Although only a depression while crossing our Archipelago SE. and S. of Manila, it developed soon into a real typhoon in the China Sea. It moved WNW. from Mindoro to Paracels; but then on the 20th it recurved N. and probably even to N. by E. passing a few miles to the W. of Hongkong on the 22d. The steamers *President Taft* and *President McKinley* were involved in the storm while near Hongkong or anchored in Kowlon Harbor, Hongkong. The barometric minimum on board the steamer *President McKinley* was 29.18.[1] The typhoon was quite severe in Hongkong and Macao. Once in China, the typhoon inclined again westward. The daily positions of the center at 6 a.m. for the period July 17 to 22 were as follows:

July 17, 133° 05′ longitude E., 10° 15′ latitude N.
July 18, 126° 15′ longitude E., 13° 20′ latitude N.
July 19, 119° 20′ longitude E., 13° 30′ latitude N.
July 20, 114° longitude E., 15° 45′ latitude N.
July 21, 112° 20′ longitude E., 18° 15′ latitude N.
July 22, 113° 05′ longitude E., 20° 15′ latitude N.

*The Luzon and Hongkong typhoon of July 17 to 29, 1923.*—This typhoon seems to have formed on July 17 to 18 to the south of Guam, not far from 144° longitude E. and 9° latitude N. It moved NW. on the 18th and 19th, W. from the 20th to the 23d or 24th. On the 24th, while in about 127° longitude and 16° latitude it took a WNW. direction, threatening the northernmost part of Luzon and the neighboring Colony of Hongkong. The barometric minimum observed in the Philippines was that of Aparri in the northern coast of Luzon, 733.9 mm. (28.89 inches) at 11 a. m. of the 25th. We do not know the exact minimum recorded at Hongkong, but the regular weather report for 6 a. m. of the 27th gave a barometric reading as low as 739.7 mm. (29.12 inches) with a gale blowing from NNW. The center must have passed practically over Hongkong or very close to the north.

The daily positions of the center at 6 a. m. for the period July 24 to 27 were approximately as follows:

July 24, 126° 40′ longitude E., 16° 10′ latitude N.
July 25, 122° 35′ longitude E., 18° 05′ latitude N.
July 26, 118° 30′ longitude E., 20° 15′ latitude N.
July 27, 114° 25′ longitude E., 22° 20′ latitude N.

Besides these two typhoons, another one was shown in our weather maps to the east and northeast of the Philippines. The center appeared on the 10th to the SE. of Yap in about 141° longitude E. and 6° latitude N. It moved WNW. first and then inclined northward about 300 miles to the E. of Luzon on the 12th. From the 13th to the 17th it moved practically north and finally filled up over the Eastern Sea near the Loochoos on the 17th.

[1] The barometric readings given in this article are not corrected for gravity.

## A TROPICAL STORM WEST OF HAWAII.

By Thomas A. Blair, Meteorologist.

[Weather Bureau, Honolulu, Hawaii, August 31, 1923.]

The U. S. S. *Vega* at noon August 20, 1923, encountered a well-developed tropical cyclone in latitude 21° 00′ N., longitude 165° 00′ W., about 450 miles west of Honolulu. Such storms are extremely rare in these waters, and indeed appear to have been previously unrecorded in the summer season. The excellent report of the storm made by Lieut. P. J. Gundlach, U. S. Navy, follows:

Left Guam for Pearl Harbor on 9th August, 1923. Up to 20th August very little change in weather conditions; about 50 per cent overcast and cloudy with some rain, wind from east and northeast, force 3 to 4.

About midnight 20th August wind increased to force 5, barometer normal. Wind increasing from that time, barometer falling slowly, 0.01 to 0.02 per hour. At 5 a. m. wind increased to force 7, same direction (45° true), barometer falling 0.04 in one hour. Heavy swells commenced from the southeast, wind veering [backing] to north. Heavy cross sea commenced. From 5 a. m. to noon wind increased from force 7 to 11 and barometer dropped from 29.84 to 29.32, largest drop 0.14 between 9 and 10 a. m. About 12:30 barometer commenced rising and wind veered [backed] to left to about northwest. From 1 p. m. wind veering [backing] to left, to west and then south, decreasing in force, weather moderating. At 5 p. m. wind south, force 6, barometer 29.71; barometer rising to 29.96 at midnight; no change in force and direction of wind. Then gradual change in wind to left, south to east, and barometer steadily rising to normal. Next day, conditions normal, sky clear.

At noon, 20th, at period of lowest barometer, sky cleared and sun shone brightly about 20 minutes, apparently "eye of storm center."

This was evidently a typical cyclone of small dimensions. On the same date high seas from the southwest occurred on the southwest coast of Kauai, approximately 21° 50′ N., 159° 40′ W. These subsided on the 21st. The only effect on the weather at Honolulu was the interruption of the trade winds on a portion of the 21st and 22d by light variable breezes from a southerly quadrant, accompanied by increased cloudiness, and on the 23d by the highest temperature recorded for two years.

No further report of the storm has been received,[2] and its origin and path remain unknown. Pressure at Midway Island, Honolulu, and Hilo remained normal. Although there was simultaneously an area of low pressure in Alaskan waters, pressure records at Midway Island and Honolulu and from ship reports indicate that there was no break in the belt of high pressure in middle latitudes. It does not seem probable, therefore, that this storm was in any way influenced in its origin by the northern LOW, as frequently appears to be the case with the winter storms known as "Konas." The storm may, however, have moved northward and merged with the northern LOW on the 22d, since the observations on the afternoon of the 21st and the morning of the 22d indicate that the center of high pressure had moved eastward, and that the Alaskan LOW had extended southward a considerable distance between the 150th and 160th meridians.

Visher[3] found a record of 70 tropical cyclones occurring in the northeast Pacific between the years 1832 and 1922, only 7 of which are recorded west of the 155th meridian, west longitude, and all of these occurred in October, November, or December. The present storm of independent tropical origin thus appears to be unique in this part of the ocean at this season of the year.

[2] See review of weather over the North Pacific Ocean.

[3] S. S. Visher, MO. WEATHER REV., 50: 295, 296.

# DETAILS OF THE WEATHER IN THE UNITED STATES.

## GENERAL CONDITIONS.

By ALFRED J. HENRY.

The weather of the current month was not greatly different from that of the preceding month; perhaps its distinguishing characteristic was a rather decided increase in barometric pressure both above the normal and as compared with the preceding month. This increase can be traced back to the movement of anticyclones which apparently originated either in the Canadian Northwest or in the bordering States of the Union—Montana and North Dakota. Like the preceding month, the high temperature normally expected in August, especially in northeastern district, was characterized by alternating periods of cool weather. The usual details follow.

## CYCLONES AND ANTICYCLONES.

By W. P. DAY.

Low-pressure areas were typical of the month of August, with centers of minimum pressure moving along the northern border or in southern Canada and often with secondary developments over central districts along the line of demarcation between the northerly and southerly components of the wind.

The approach of the winter season was heralded by a marked increase in the number of high-pressure areas of the so-called Alberta type. Seven of these cooler masses of air moved down from the Canadian Northwest, while eastern Canada, which had been so prolific in HIGHS during July, produced none.

## FREE-AIR SUMMARY.

By L. T. SAMUELS, Meteorologist.

The Broken Arrow aerological station was situated, during the month, in the region of largest positive temperature departures as shown on Climatological Chart III. This affords opportunity for observing the extent to which such departures prevailed in the free air. It will be noted from Table 1 that the departures at this station decrease with altitude becoming opposite in sign at the highest levels. During the hot period which occurred in this section the first part of the month absolute record temperatures were observed at this station from the surface to 1,000 meters above. At Groesbeck previous August high temperatures were exceeded from the 1,000 to the 2,000 meter level during this period. At Ellendale, where surface departures were appreciably negative, the higher levels showed a persistence in this respect, although of smaller magnitude. The cold wave of the 22d brought temperatures lower than during any previous August since the establishment of the stations at Ellendale and Royal Center from the surface to 2,000 meters above. During this period the largest departure from the normal (15° C.) was found at the 1,000 meter level at Ellendale.

Humidities averaged generally above normal at Drexel and Ellendale and below at the other stations.

Vapor pressure departures were negative except at Drexel and the lower levels at Due West and the upper levels at Broken Arrow and Ellendale.

The resultant winds are shown in Table 2, and of particular interest among these are Ellendale and Royal Center where the northerly component for the month predominated instead of the normal southerly. This is in harmony with the negative temperature departures found at those stations. Pilot balloon observations at Groesbeck showed a persistent turning of the winds with altitude to easterly above 3,000 meters from the 1st to the 24th. During the remainder of the month the winds at these upper levels changed to westerly. This undoubtedly indicates the transition from summer to autumn conditions with the southward migration of the thermal equator. During this transition period we would expect to find light winds to considerable altitudes and that this occurred is shown by the interesting pilot balloon observation obtained at Groesbeck on the 24th. The balloon was observed with two theodolites for 81 minutes, at the end of which time the computed height was 15,360 meters. This is the highest two-theodolite observation on record in this country, and it is of special interest in that it indicates such excellent agreement with the assumed ascensional rate used in single-theodolite work. The assumed rate would have given 15,670 meters, or only 310 meters higher.

Numerous other two-theodolite observations obtained during recent months extending nearly to this height give assured evidence that single-theodolite observations are strikingly dependable to these great heights. In the lower levels, however, especially during the early after-

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noon, pronounced convection undoubtedly affects the ascensional rate appreciably. After the balloon has risen above this convective turbulence the constant rate is again maintained. As an illustration of an unusually strong convectional influence the two-theodolite observation at Broken Arrow on the afternoon of the 14th is cited. It was found that convection affected the ascensional rate until the 22d minute. However, from the 22d to the 55th minute, the end of the observation, the ascensional rate was almost exactly that of the assumed rate used in single-theodolite work. That conditions extremely favorable for convection were prevalent is shown by the kite records from Broken Arrow on this date and that following. It is found that the lapse rate was particularly steep on these dates, exceeding 2° C. per 100 meters off the surface on the 14th and over 1° C. per 100 meters from the surface to 3,000 on the 15th. Low humidity at these times, however, prevented thunderstorm development.

The observation at Groesbeck on the 24th, referred to above, showed westerly winds from 4,000 to 15,000 meters with an average velocity of about 8 m. p. s. On the 2d, a two-theodolite observation at this station reached to nearly 14,000 meters, indicating moderate easterly winds from 3,000 meters to the highest altitude.

Exceedingly strong winds were observed in the free air as follows: Ellendale on the 7th, W. 39 m. p. s., 7,600 meters; Lansing, W. 31 m. p. s., 8,400 meter; Burlington, WNW. 41 m. p. s., 4,800 meters. It is found that on these dates a high pressure area central over North Dakota on the 7th moved practically due east, being central over Lake Huron on the 9th. In these strong winds undoubtedly lies the reason for the direction taken by this HIGH, since it is oftener found that a more southerly course is followed.

During periods when the Atlantic HIGH was particularly well developed an easterly wind of considerable velocity was observed in the free air at San Juan. This reached 20 m. p. s. at 1,500 meters on the 10th; 23 m. p. s. at 3,500 meters on the 21st; and 23 m. p. s. at 2,000 meters on the 22d.

TABLE 1.—*Free-air temperatures, relative humidities and vapor pressures during August, 1923.*

TEMPERATURE (°C.).

| Altitude. m. s. l. (m.) | Broken Arrow, Okla. (233m.) | | Drexel, Nebr. (396m.) | | Due West, S. C. (217m.) | | Ellendale, N. Dak. (444m.) | | Groesbeck, Tex. (141m.) | | Royal Center, Ind. (225m.) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean. | Departure from 6-yr. mean. | Mean. | Departure from 8-yr. mean. | Mean. | Departure from 3-yr. mean. | Mean. | Departure from 6-yr. mean. | Mean. | Departure from 5-yr. mean. | Mean. | Departure from 6-yr. mean. |
| Surface | 28.5 | +1.5 | 21.4 | −1.1 | 27.2 | +1.6 | 18.0 | −2.6 | 27.2 | +0.4 | 23.0 | −0.8 |
| 250 | 28.4 | +1.5 | ..... | ..... | 26.8 | +1.6 | ..... | ..... | 26.3 | +0.4 | 22.7 | −0.9 |
| 500 | 27.1 | +1.7 | 21.1 | −1.0 | 24.1 | +1.5 | 17.9 | −2.5 | 24.6 | +0.4 | 20.1 | −1.3 |
| 750 | 25.9 | +1.7 | 20.5 | −0.7 | 22.6 | +1.7 | 17.3 | −2.2 | 23.6 | +0.5 | 18.5 | −1.2 |
| 1,000 | 24.2 | +1.3 | 19.3 | −0.9 | 20.5 | +1.1 | 16.3 | −2.0 | 22.6 | +0.6 | 16.8 | −1.3 |
| 1,250 | 22.6 | +1.2 | 18.1 | −0.9 | 18.8 | +0.9 | 15.1 | −1.8 | 21.4 | +0.7 | 15.1 | −1.5 |
| 1,500 | 20.9 | +1.1 | 17.0 | −0.6 | 17.0 | +0.7 | 13.8 | −1.6 | 20.0 | +0.7 | 14.0 | −1.2 |
| 2,000 | 17.1 | +0.9 | 14.3 | −0.2 | 13.7 | +0.4 | 11.5 | −1.0 | 17.0 | +0.7 | 11.6 | −0.8 |
| 2,500 | 13.2 | +0.4 | 11.4 | +0.1 | 10.4 | +0.3 | 8.8 | −0.8 | 14.5 | +1.1 | 9.2 | −0.7 |
| 3,000 | 9.3 | −0.2 | 8.2 | +0.3 | 7.8 | +0.5 | 5.8 | −1.0 | 11.3 | +0.7 | 6.8 | −0.5 |
| 3,500 | 5.6 | −0.6 | 4.7 | +0.2 | 5.2 | +0.7 | 2.6 | −1.3 | 8.0 | −0.2 | 4.0 | −0.7 |
| 4,000 | 1.9 | −0.8 | 1.3 | +0.2 | 1.4 | +0.5 | −0.6 | −1.5 | 5.2 | −0.5 | −0.4 | −2.4 |
| 4,500 | −1.9 | −0.8 | −2.1 | +0.4 | ..... | ..... | −3.2 | −1.0 | 2.8 | +0.1 | ..... | ..... |
| 5,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.2 | +0.1 | ..... | ..... |

RELATIVE HUMIDITY (%).

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface | 56 | −10 | 76 | +6 | 70 | 0 | 72 | +7 | 67 | −6 | 65 | 0 |
| 250 | 56 | −10 | ..... | ..... | 71 | 0 | ..... | ..... | 69 | −5 | 65 | 0 |
| 500 | 55 | −9 | 73 | +6 | 73 | −1 | 70 | +6 | 70 | −4 | 63 | −2 |
| 750 | 54 | −8 | 67 | +5 | 73 | −2 | 63 | +3 | 64 | −4 | 63 | −3 |
| 1,000 | 54 | −7 | 67 | +7 | 77 | +1 | 61 | +2 | 58 | −5 | 65 | −1 |
| 1,250 | 53 | −8 | 66 | +7 | 78 | +1 | 59 | +1 | 54 | −7 | 62 | −4 |
| 1,500 | 53 | −8 | 65 | +7 | 78 | +1 | 59 | +1 | 54 | −7 | 57 | −8 |
| 2,000 | 56 | −7 | 65 | +7 | 71 | −2 | 55 | −1 | 55 | −6 | 53 | −9 |
| 2,500 | 60 | −3 | 66 | +8 | 70 | −3 | 57 | +3 | 50 | −9 | 48 | −9 |
| 3,000 | 63 | +1 | 63 | +4 | 66 | −7 | 58 | +6 | 48 | −9 | 40 | −10 |
| 3,500 | 69 | +6 | 63 | +5 | 65 | −7 | 62 | +12 | 42 | −9 | 36 | −10 |
| 4,000 | 71 | +5 | 66 | +10 | 73 | +1 | 78 | +27 | 36 | −5 | 46 | −2 |
| 4,500 | 68 | +5 | 64 | +8 | ..... | ..... | 78 | +27 | 30 | −8 | ..... | ..... |
| 5,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 23 | −8 | ..... | ..... |

VAPOR PRESSURE (*mb*).

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface | 20.96 | −1.77 | 19.34 | +0.68 | 24.98 | +1.99 | 14.87 | −0.37 | 23.54 | −1.74 | 18.83 | −0.10 |
| 250 | 20.83 | −1.73 | ..... | ..... | 24.67 | +2.00 | ..... | ..... | 23.07 | −1.39 | 18.48 | −0.23 |
| 500 | 19.13 | −1.11 | 18.33 | +0.65 | 21.96 | +1.75 | 14.42 | −0.50 | 21.27 | −0.81 | 15.49 | −1.00 |
| 750 | 17.55 | −0.58 | 15.89 | +0.24 | 20.02 | +1.48 | 12.56 | −0.78 | 18.35 | −0.82 | 14.04 | −0.99 |
| 1,000 | 16.06 | −0.51 | 14.59 | +0.43 | 18.56 | +1.43 | 11.31 | −0.79 | 15.84 | −0.89 | 12.99 | −0.83 |
| 1,250 | 14.58 | −0.53 | 13.43 | +0.54 | 16.79 | +1.06 | 10.18 | −0.83 | 13.95 | −1.04 | 11.12 | −1.58 |
| 1,500 | 13.19 | −0.49 | 12.33 | +0.61 | 14.84 | +0.69 | 9.45 | −0.54 | 12.83 | −0.99 | 9.47 | −1.94 |
| 2,000 | 11.15 | −0.21 | 10.72 | +0.93 | 10.77 | −0.21 | 7.68 | −0.27 | 10.64 | −0.80 | 7.58 | −1.54 |
| 2,500 | 9.32 | +0.24 | 9.22 | +1.15 | 8.45 | −0.49 | 6.56 | +0.16 | 8.38 | −1.04 | 5.76 | −1.47 |
| 3,000 | 7.66 | +0.46 | 7.20 | +0.58 | 7.00 | −0.32 | 5.69 | +0.51 | 6.33 | −1.42 | 3.76 | −1.61 |
| 3,500 | 6.38 | +0.61 | 5.91 | +0.62 | 5.67 | −0.21 | 5.20 | +1.02 | 4.46 | −1.64 | 3.00 | −1.29 |
| 4,000 | 4.90 | +0.38 | 5.21 | +1.12 | 4.95 | +0.31 | 5.12 | +1.66 | 3.25 | −1.28 | 3.21 | −0.50 |
| 4,500 | 3.39 | +0.38 | 3.86 | +0.81 | ..... | ..... | 4.32 | +1.49 | 2.26 | −1.67 | ..... | ..... |
| 5,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.54 | −1.67 | ..... | ..... |

TABLE 2.—*Free-air resultant winds (m. p. s.) during August, 1923.*

| Altitude. m. s. l. (M.) | Broken Arrow, Okla. (233 m.) | | | | Drexel, Nebr. (396 m.) | | | | Due West, S. C. (217 m.) | | | | Ellendale, N. Dak. (444 m.) | | | | Groesbeck, Tex. (141 m.) | | | | Royal Center, Ind. (225 m.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean. | | 6-year mean. | | Mean. | | 8-year mean. | | Mean. | | 3-year mean. | | Mean. | | 6-year mean. | | Mean. | | 5-year mean. | | Mean. | | 6-year mean. | |
| | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dr. | Vel. | Dir. | Vel. | Dir. | Vel. |
| Surface | S. 25°W. | 3.0 | S. 2°W. | 3.3 | S. 28° E. | 0.5 | S. 14° E. | 1.5 | S. 52°W. | 2.2 | S. 3°W. | 0.2 | N. 12°E. | 1.3 | S. 37°W. | 0.8 | S. 11°W. | 3.3 | S. 15°W. | 3.1 | N. 68°W. | 1.2 | S. 66°W. | 1.5 |
| 250 | S. 26°W. | 3.2 | S. 1°W. | 3.4 | ..... | ..... | ..... | ..... | S. 52°W. | 2.3 | S. 19°W. | 0.3 | ..... | ..... | ..... | ..... | S. 13°W. | 4.2 | S. 17°W. | 4.1 | N. 73°W. | 1.4 | S. 67°W. | 1.7 |
| 500 | S. 42°W. | 5.7 | S. 14°W. | 4.9 | S. 25° E. | 0.8 | S. 8° E. | 2.1 | S. 58°W. | 3.2 | S. 72°W. | 0.6 | N. 21° E. | 1.2 | S. 29°W. | 1.1 | S. 20°W. | 5.5 | S. 24°W. | 5.8 | N. 80°W. | 3.9 | S. 68°W. | 3.6 |
| 750 | S. 53°W. | 6.0 | S. 21°W. | 5.6 | S. 26° E. | 1.1 | S. 5°W. | 3.0 | S. 61°W. | 3.4 | S. 83°W. | 0.8 | N. 17° E. | 0.8 | S. 31°W. | 2.1 | S. 20°W. | 5.2 | S. 22°W. | 5.8 | N. 71°W. | 6.1 | S. 75°W. | 4.4 |
| 1,000 | S. 54°W. | 5.7 | S. 29°W. | 5.8 | S. 3°W. | 0.5 | S. 24°W. | 3.2 | S. 61°W. | 3.5 | S. 78°W. | 0.8 | N. 44°W. | 1.2 | S. 43°W. | 2.3 | S. 16°W. | 5.1 | S. 23°W. | 5.8 | N. 68°W. | 9.0 | S. 82°W. | 5.6 |
| 1,250 | S. 55°W. | 5.0 | S. 37°W. | 5.6 | S. 76°W. | 1.4 | S. 38°W. | 3.4 | S. 67°W. | 4.0 | S. 84°W. | 1.3 | N. 60°W. | 2.2 | S. 56°W. | 2.7 | S. 16°W. | 4.8 | S. 22°W. | 5.4 | N. 61°W. | 11.0 | S. 87°W. | 6.2 |
| 1,500 | S. 60°W. | 4.5 | S. 43°W. | 5.3 | N. 88°W. | 2.2 | S. 52°W. | 3.8 | S. 67°W. | 4.7 | S. 83°W. | 2.2 | N. 66°W. | 3.6 | S. 67°W. | 3.2 | S. 10°W. | 4.1 | S. 19°W. | 4.8 | N. 58°W. | 11.6 | W. | 6.9 |
| 2,000 | S. 64°W. | 3.7 | S. 49°W. | 4.6 | W. | 3.5 | S. 68°W. | 5.0 | S. 74°W. | 6.0 | N. 89°W. | 2.8 | N. 66°W. | 6.6 | S. 83°W. | 4.5 | S. 4° E. | 3.2 | S. 13°W. | 3.9 | N. 57°W. | 12.6 | W. | 7.9 |
| 2,500 | S. 58°W. | 3.9 | S. 54°W. | 4.9 | N. 74°W. | 5.9 | S. 76°W. | 6.3 | S. 77°W. | 6.8 | N. 86°W. | 4.0 | N. 64°W. | 10.0 | N. 87°W. | 9.2 | S. 2°W. | 3.0 | S. 19°W. | 4.0 | N. 56°W. | 12.5 | N. 85°W. | 9.1 |
| 3,000 | S. 54°W. | 4.0 | S. 55°W. | 5.9 | N. 65°W. | 8.8 | S. 84°W. | 8.2 | S. 80°W. | 8.7 | W. | 5.8 | N. 60°W. | 13.2 | N. 80°W. | 8.1 | S. 35°W. | 2.9 | S. 24°W. | 4.3 | N. 54°W. | 14.6 | N. 82°W. | 10.7 |
| 3,500 | S. 57°W. | 6.0 | S. 50°W. | 7.2 | N. 71°W. | 10.2 | S. 85°W. | 9.2 | S. 76°W. | 10.9 | S. 86°W. | 7.7 | N. 61°W. | 15.5 | N. 76°W. | 10.8 | S. 45° E. | 11.4 | S. 17°W. | 4.9 | N. 57°W. | 16.3 | N. 85°W. | 10.5 |
| 4,000 | W. | 6.7 | S. 65°W. | 10.2 | N. 58°W. | 15.5 | S. 89°W. | 10.6 | S. 85°W. | 11.8 | N. 87°W. | 8.9 | N. 60°W. | 15.7 | N. 74°W. | 11.1 | S. 45° E. | 11.8 | N. 32° E. | 2.8 | W. | 17.8 | S. 88°W. | 12.1 |
| 4,500 | W. | 8.0 | W. | 8.0 | N. 45°W. | 14.4 | N. 69°W. | 10.5 | S. 83°W. | 10.3 | N. 86°W. | 11.8 | N. 45°W. | 15.3 | N. 76°W. | 10.5 | S. 45° E. | 12.2 | S. 45° E. | 12.2 | W. | 17.7 | S. 80°W. | 11.5 |
| 5,000 | ..... | ..... | ..... | ..... | N. 45°W. | 14.2 | N. 72°W. | 13.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | S. 45° E. | 12.6 | S. 45° E. | 12.6 | ..... | ..... | ..... | ..... |

## THE WEATHER ELEMENTS.

By P. C. DAY, Meteorologist, in Charge of Division.

### PRESSURE AND WINDS.

August, 1923, on the whole exhibited no radical departures from the weather to be expected during the last month of summer, although over much of the northern and central portions of the country from the Rocky Mountains eastward the elements favoring the oppressive weather usually associated with the so-called dog days were largely lacking and pleasant weather was the rule.

The cyclonic circulation continued feeble and the centers of low-pressure areas pursued tracks usually well to the northward from the Great Lakes eastward, only one, that of the 21st–22d, developing the more important cyclonic features.

Anticyclones were of a somewhat stronger type than usually prevail in August, particularly over the western

districts, that of the 21st–22d, moving southward from the Canadian Northwest, being of unusual strength and giving the first warning of approaching winter over northern and central districts from the Rocky Mountains eastward.

In the absence of important low-pressure areas over the southern districts, from Texas eastward, frequently associated with West India hurricanes, the average pressure for the month over this area was higher than in July, although the reverse is usually the case. Likewise on account of the prevalence of low areas along the northern border from the Great Lakes eastward the average pressure for this region was distinctly lower than in July, and here, too, the reverse is usually the case.

For the month as a whole pressure was slightly below normal from the central portions of Kansas and Oklahoma northeastward and eastward to the Great Lakes and Atlantic coast. Elsewhere the pressure averages were above the normal for the month.

High winds prevailed over extensive areas from the upper Mississippi Valley eastward over the Great Lakes and to the North Atlantic coast on the 21st and 22d, during the passage eastward of the most important storm of the month over those regions. At Buffalo, N. Y., a maximum velocity of 72 miles per hour was recorded on the 21st, the highest ever reported from that point in August.

Except in the above instance high winds were limited to small thunderstorm areas, and as far as reported no lives were lost from storms of the tornado type, and little property damage was sustained from windstorms of any character.

The prevailing winds were from southerly points over most Atlantic Coast States, and from the Ohio and lower Missouri Valley to the Gulf of Mexico. From the upper Missouri Valley eastward to the Great Lakes the prevailing winds were mainly from northerly or westerly points, while from the Rocky Mountains westward they were variable.

A list of the more important storms of the month, with items pertaining to location, damage, etc., appears at the end of this section.

## TEMPERATURE.

The outstanding feature of the temperature conditions during the month was the unusual cold attending the strong anticyclone that moved into the upper Missouri Valley from the British Northwest on the morning of the 21st, and during the following two or three days overspread the northern and central districts of the United States from the Rocky Mountains eastward. Some of the lowest temperatures ever recorded in August occurred during this period, particularly in the Great Lakes region, and at numerous other points the temperatures were the lowest ever observed so early in the month.

Frosts were reported from exposed localities in the more Northern States, and some damage resulted to corn, buckwheat, and garden truck.

During the progress southward and eastward of this cold area temperature changes amounting to 20° or more in 24 hours occurred over extensive areas, but otherwise the changes from day to day were usually unimportant.

The following is a statement of the more important features of the temperature conditions existing during the several weeks of the month:

During the week ending the 7th, high temperatures continued, as had been the case for several previous weeks, over the Central and Southern Plains, the greatest heat centering over Oklahoma and portions of adjacent States, where the day temperatures were frequently above 100°, reaching a maximum of 112° on the 1st, with weekly averages ranging from 6° to 10° per day above the normal. This week was warm as a rule over practically all other portions of the country from New Mexico northeastward to the Lake Superior region and thence eastward to the Atlantic coast, save over Florida and small areas adjacent thereto. In the upper Missouri Valley and generally to westward of the Rocky Mountains, this week was cooler than normal, the averages for the period ranging from 6° to 12° below normal, from western Minnesota to the eastern portions of Washington and Oregon.

The second week of the month continued warm generally over practically all districts from the Rocky Mountains eastward, the center of the greatest heat still persisting over Oklahoma and parts of adjacent States, with averages about as high as during the preceding week, and extremes still above 100° or only slightly less, and reaching a maximum of 113° in Kansas on the 14th. West of the Rocky Mountains this week showed some increase in warmth, but the averages were still usually lower than normal.

The week ending the 21st had more veriable temperature conditions than had existed previously during the month, although high temperatures still persisted in the Southern Plains. Over most districts from the Great Lakes eastward the week was moderately cool and similar conditions prevailed in the middle and southern Rocky Mountain and Plateau districts and in the interior portions of California. It was slightly warmer than normal in the far Northwest and the week continued warm in the Great Plains and over most central and southern districts to the eastward.

Beginning with the morning of the 21st unseasonably low temperatures overspread the upper Missouri Valley, and during the following few days decidedly cool weather for August prevailed over most central and northern districts from the Rocky Mountains eastward, the week following the 21st as a whole averaging from 6° to 10° below the normal over all northern districts from the Dakotas and Nebraska eastward to the North Atlantic States. The week was likewise cooler, but not to such a marked degree, over all other portions of the country, save in the Plateau and Pacific Coast States and at a few points in the more Southern States.

The last few days of the month were without important variations in temperature and at the close nearly normal conditions prevailed in all parts of the country.

The month as a whole was decidedly warm over the near Southwest, the area of greatest heat centering over Oklahoma and the adjacent portions of near-by States. It was likewise warmer than average in the far Northwest and over the Atlantic Coast States from North Carolina to central Florida. Elsewhere the month was cooler than normal, the greatest deficiencies appearing over the more northern districts from the Dakotas eastward.

The warmest periods of the month were mainly during the first half, important dates being on the 1st over Texas, Oklahoma and parts of adjoining States, and in the upper Lake region; on the 3d to 5th over the Northeastern States; about the 10th to 12th from the middle Rocky Mountains eastward to the Ohio Valley; about the 15th to 18th in the central and east Gulf States and in the far Northwest; and near the end over California, Arizona and portions of adjoining States.

The coolest period of the month was confined chiefly to the early part of the last decade, mainly on the 22d–24th. Over the districts from the Rocky Mountains westward the coolest days were widely scattered.

### PRECIPITATION.

The rainfall during the month was probably near the normal considering the country as a whole, though poorly distributed as a rule. In general there was less than the normal amount from central Montana and northern Wyoming eastward to the Great Lakes, over the Atlantic States from Maine to Florida, and over the Great Plains from the southern portions of Kansas and Missouri to the Gulf and Rio Grande. Over the Plateau States and from the middle Rocky Mountains eastward to Lake Michigan and the Ohio Valley the precipitation was above normal, usually by considerable amounts. In eastern Colorado and portions of Nebraska, South Dakota and Iowa rains were frequent and heavy, and the totals for the month were in many cases the greatest of record for August. In Colorado rain occurred in some portions of the State on every day of the month, and the total for the State was the greatest ever known in August.

The greatest monthly fall at any station was 14.30 inches at Georgetown, S. C., and amounts above 10 inches were reported from one or more points in nearly half the States. The range between the greatest and least amounts was unusually large, thus indicating a very uneven distribution within the States.

### SNOWFALL.

Snow was reported from some of the mountains of Wyoming and Montana, on the 1st, but records available do not show that it occurred elsewhere.

The supply of water for irrigation and hydroelectric power in California was low, but sufficient for present needs. Elsewhere in the West the supply of water was generally sufficient.

### RELATIVE HUMIDITY.

On account of the prevailing high temperatures in portions of the middle and southern Great Plains, the relative humidity over this area ranged from 5 to 15 per cent less than normal, and there was a general deficiency from the upper Mississippi Valley eastward to New England. In other parts of the country more humid conditions prevailed and there was a decided excess in the Rocky Mountain and portions of the Plateau regions.

## SEVERE LOCAL STORMS, AUGUST, 1923.

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau.]

| Place. | Date. | Time. | Width of path (yards). | Loss of life. | Value of property destroyed. | Character of storm. | Remarks. | Authority. |
|---|---|---|---|---|---|---|---|---|
| Modena, Utah (near) | 1 | P. m. | | | | Thunderstorm and hail. | High water resulted in washing out fences and crops and overflowing railroad track. | Official, U. S. Weather Bureau. |
| Yankton, S. Dak., and vicinity. | 3 | 9:35–10:50 p. m. | | | | Thunderstorm | Much damage to wires and poles, trees, and signs; minor damage to some buildings; corn blown down; 2 persons injured. | Official, U. S. Weather Bureau. Press and Dakotan (Yankton, S. Dak.). |
| Garden City, Kans. | 4 | P. m. | | | | Wind and hail | Crops severely damaged. | Official, U. S. Weather Bureau. |
| Leoti, Kans. | 4 | 5 p. m. | | | | Tornado | Whole town practically destroyed; several persons injured. | Official, U. S. Weather Bureau. Wichita Beacon. |
| Terre Haute, Ind., and adjacent country. | 4 | 5–8 p. m. | | | | Thunderstorm | Communication crippled and car service interrupted for several hours; other minor damage. | Official, U. S. Weather Bureau. Star (Terre Haute, Ind.). |
| Beech Grove, Ky. (vicinity of) | 4 | A. m. | | | | Wind and rain | Considerable damage to barns and crops. | Inquirer (Owensboro, Ky.) |
| Central Illinois | 4–5 | | | | | Electrical and wind. | Communication and transportation lines damaged; corn blown down and trees uprooted or broken; other minor damage. | Official, U. S. Weather Bureau. State register. (Springfield, Ill.). |
| West Springfield, Mass. | 5 | 2:30 p. m. | 67 | | | Tornado | Many buildings demolished and others unroofed and some minor property damage; a number of people were injured; length of path one-half mile. | Official, U. S. Weather Bureau. Springfield Daily Republican. |
| Bridgewater and Middleboro, Mass. | 5 | | | | | Wind | Trees blown down and corn and potatoes damaged. | Official, U. S. Weather Bureau. |
| Charles City, Iowa, and vicinity. | 6 | 7:45–9 p. m. | | | $6,000 | Thunderstorm | Residence damaged, and barn destroyed by lightning. | Do. |
| Nashville, Tenn. | 6 | | | | | Electrical and wind. | 700 poles disabled, traffic suspended, and several buildings slightly damaged. | Do. |
| Terre Haute, Ind. | 7–8 | | | | | Thunderstorm | Much damage by wind and lightning. | Do. |
| St. Louis, Mo. | 8 | | | | | do | Streets and cellars flooded; telephone service crippled and street-car operation suspended for several hours. | Do. |
| Chicago, Ill. | 11 | | | | | Electrical | Several persons and a number of buildings struck by lightning. | Do. |
| Dubuque, Iowa | 11 | 10 p. m. | | | | Wind | Details not reported. | Do. |
| Fort Covington, N. Y. | 12 | | | | 20,000 | Wind and hail | Crops, silos and building damaged. | Do. |
| Indianapolis, Ind. | 12 | A. m. | | | | Thunderstorm | Minor damage reported. | Do. |
| Concordia, Kans., and vicinity | 14 | 7:52–9:47 p. m. | | | | do | Chimney destroyed by ligthning; 6 head of cattle killed. | Do. |
| Memphis, Tenn. | 17 | 7–8 p. m. | | | | Electrical and rain | About 500 telephones put out of use and many trees uprooted; several persons injured. | Do. Commercial Appeal (Tennessee). |
| Niagara and Orlean Counties, N. Y. | 21 | | | | | Gale | Fruit crops heavily damaged; some minor damage. | Official, U. S. Weather Bureau. |
| Indianapolis, Ind. | 21 | 1–4 p. m. | | | | Thunderstorm | Communication lines disabled; trees and signs blown down; several killed or injured by lightning; many streets and basements flooded. | Do. |
| Rochester, N. Y. | 21 | P. m. | | | | Wind | Electric systems damaged; navigation on Lake Ontario hindered. | Do. |
| Cincinnati, Ohio | 26 | P. m. | | | | Thunderstorm and hail. | Damage principally to windows, lamps, and skylights. | Do. Commercial Tribune (Ohio). |
| Indianapolis, Ind. | 27 | A. m. | | | | Thunderstorm | Two barns struck by lightning; some damage to wires. | Official, U. S. Weather Bureau. |
| Levy, N. Mex. | 27 | P. m. | | | | Wind, rain, and hail. | Damage by flooding. | The Journal (Albuquerque, N. Mex.). |
| Chicago, Ill. | 27 | A. m. | | | | Wind, rain, and electrical. | Telephone and electric power lines torn down; basements and subways flooded; numerous fires reported from lightning. | Daily Journal (Chicago, Ill.). |
| San Francisco, Calif. (vicinity of). | 28 | | | | 500,000 | Thunderstorm | Standard Oil tanks in San Pablo struck by lightning; minor damage in other near by points. | Official, U. S. Weather Bureau. |
| Savannah, Ga. | 30 | | | | | Wind | Considerable property damage. | Do. |

## STORMS AND WEATHER WARNINGS.

By EDWARD H. BOWIE, Supervising Forecaster.

### WASHINGTON FORECAST DISTRICT.

The first and second decades of the month were without unusual meteorological features. During much of the time the prevailing conditions were those normal to the month, i. e., quite warm and humid and more or less showery. A radical change from the previously prevailing type of weather and temperature set in near the close of the second decade, when on the 21st, an extensive area of high barometric pressure with attendant cool weather appeared over the Northwestern States. At the same time, the barometric pressure was high off the South Atlantic coast. Between these two systems of high pressure there was a well-defined trough of low pressure, extending from the Great Lakes southwestward to Mexico, in which a cyclone of considerable intensity formed during the succeeding 24 hours. This disturbance gained great intensity while passing eastward to the Canadian Provinces and necessitated the display of storm warnings on the North Atlantic coast at 9 p. m. of the 21st. Previously, at 11 a. m. of the same day, the following advisory information was sent Atlantic ports and disseminated by radiotelegraph:

> Disturbance over Great Lakes will increase in intensity and move eastward. The winds will become fresh and possibly strong on the North Atlantic coast late to-night and Wednesday morning, with showers and probably fog.

As this disturbance passed over Newfoundland the pressure at or near its center read slightly below 29 inches. Following the disturbance in question, the northwestern area of high barometer spread eastward and southward and brought the first pronounced cool wave of the late summer to nearly all parts of the country east of the Rocky Mountains, and at a number of points in the Northern States produced the lowest temperatures of record for the month of August. It was attended by light frosts along the northern border of the Washington Forecast District. Moreover, it required the issue on the 21st and 22d of frost warnings for the cranberry bogs of New Jersey and Massachusetts.

Following the cool wave referred to in the preceding paragraph, the weather quickly returned to normal and nothing of an unusual nature occurred during the remainder of the month in the Washington Forecast District, although smalf-craft warnings were necessary and were issued for the North Atlantic coast on the 28th, when a cyclone of moderate intensity was passing down the St. Lawrence Valley. Fresh and strong winds and squalls occurred on the North Atlantic coast the afternoon and night of the 28th.

The region of the West Indies and the Gulf of Mexico were free from tropical cyclones during the month, this being accounted for by reason of the fact that the northeast trade extended well south to the north coast of South America throughout the month. Nevertheless, there were indications furnished by abnormal wind directions, the evening of the 29th that there was a disturbance some distance to the eastward of the island of St. Martin and the following advisory information was sent the District Forecaster at San Juan, Porto Rico:

> Slight indications tonight of a disturbance some distance east of St. Martin. It is questionable whether it is fully organized.

No further trace was had of this disturbance until several days later when it affected the wind and weather conditions at Bermuda, the winds becoming fresh and strong with heavy rains thereabouts during September 2 to 4. Subsequently this disturbance moved northward and appeared on the 9th, as shown by meteorological observations received by radio, as a disturbance of considerable severity south of Newfoundland. The path of this disturbance will be shown in the September number of the MONTHLY WEATHER REVIEW.

### CHICAGO FORECAST DISTRICT.

Perhaps the most noteworthy feature of the weather conditions in the Chicago Forecast District during August, 1923, was the occurrence, early in the last deecade, of a general cool wave that resulted in frost in portions of North Dakota, Minnesota, Wisconsin, Michigan, and northern Indiana. At Detroit, Mich., the temperature fell to 44°, the lowest of record in August at that station. Generally speaking, only slight damage was caused by the frosts. The accompanying high-pressure area was of rather unusual intensity and magnitude for the season. Closely following this cool wave was another, but the area affected was confined to eastern North Dakota, northern Minnesota, and Wisconsin. Over those States light frost occurred in areas, but in a few cases the formation was heavy.

The following frost warnings were issued in connection with these two cool waves:

21st to 24th, inclusive: Wisconsin cranberry interests.

22d and 24th: Wisconsin tobacco interests.

24th: Northeastern Minnesota, northern Wisconsin, upper Michigan, northern lower Michigan.

Earlier in the month, on the 1st, 4th, 14th, and 15th, advisory frost warnings were issued for the Wisconsin cranberry interests. Although no frosts occurred on those occasions, the bog temperatures on one or two dates were only slightly above the freezing point.

The only storm warning issued during the month was that on the 21st in connection with a disturbance that on the morning of that date was central over lower Michigan, with increasing energy, it having moved rapidly eastward during the preceding 24 hours from the northern Rocky Mountain region in advance of the marked high pressure area referred to above. This disturbance continued its rapid eastward movement and by the evening of the 21st was central over the Middle St. Lawrence Valley with a still further increase in energy, the central pressure being 29.28 inches, at Montreal. In connection with this disturbance southwest storm warnings were issued on the morning of the 21st for the lower lakes, northwest warnings for Lake Huron, and small craft warnings for Lakes Michigan and Superior. In the early afternoon of the 21st northwest warnings were issued for the eastern shore of Lake Michigan. Owing to the rapid movement of the disturbance the warnings were lowered on the evening of the 21st over the last-named section, as well as over Lake Erie. All these warnings were verified.

In addition to the small-craft warnings referred to in the foregoing, the following warnings of that character were issued during the month:

13th: At Houghton, Mich., by the local official.

14th: Lakes Superior, Huron, Erie, and Ontario, by the District Forecast Center.

19th: At Alpena, Mich., by the local official.

24th: All the Great Lakes, except central and southern Lake Michigan, by the District Forecast Center.

28th: Lakes Huron, Erie, and Ontario, by the District Forecast Center.—*C. A. Donnel.*

NEW ORLEANS FORECAST DISTRICT.

During the first three weeks the areas of high pessure that appeared in the Northwest and passed eastward or dissipated were not of sufficient intensity to cause a general break in the period of hot, dry weather that prevailed in most interior sections of the western and central portions of the district.

The most important area of high pressure appeared on the 21st and its southward advance over the district terminated the drought and was attended by a period of comparatively cool weather.

Conditions were favorable during the month for frequent showers in the coast section of Louisiana.

No storm warnings were issued or required.—*R. A. Dyke.*

DENVER FORECAST DISTRICT.

No low pressure areas of importance affected the district during the month, and the temperature was considerably below the normal for August throughout the district. The month was characterized by a large number of high-pressure areas on the eastern slope, most of which moved southward from the Canadian Northwest, resulting in frequent showers and much cloudy weather in eastern Colorado. At Denver the number of rainy days was 16, being the greatest recorded at Denver in August since the year 1875.

No special warnings were issued or required.—*Frederick W. Brist.*

SAN FRANCISCO, FORECAST DISTRICT.

The only warnings issued during August were for a spell of warm weather on the 6th and for rain on the 20th. The first applied to northern California, and while warm weather prevailed for several days, it did not become as warm as expected.

The special rain warning was issued to only a few places in the counties just north of San Francisco, and it was fully verified. Many prunes were being dried in the sun in this part of the State at this time, and the warnings were received early enough to enable the growers to stack their trays, and thus protect the fruit from injury.

The principal feature of the month was the presence of a LOW off the north California coast that first appeared on the 11th, and it persisted till the end of the month. It moved every day, sometimes coming closer to the coast and other times retreating farther westward. Also at times it would move some distance to the north and again to the south. On the 16th it was quite close to the Washington coast, and a portion evidently became detached from the parent storm and crossed the Rocky Mountains on the 19th, causing showers in scattered places in the northern portion of this district on one or two days.

Another portion of the Gulf of Alaska LOW moved inland on the 21st, and in consequence good rains fell for two or three days in the North Pacific States, and unsettled weather prevailed in the northern half of California. The pressure was also relatively low over Bering Sea during practically the entire month.—*E. A. Beals.*

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## RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

Stages in nearly all rivers of the country indicated the approach of the annual low-water season that usually reaches its culmination in late autumn. Floods occurred in only a few rivers, and they were very moderate and of little consequence. Over the Saluda and Santee drainage areas of South Carolina rains were frequent and heavy, anf the rivers were above the average mean stage for August, with floods occurring at the close of the month in both rivers. Warnings were issued at the proper time and no losses were reported, as no crops had been planted in the lowlands on account of continued high water. Stages were also quite high at the same time in the interior rivers of Georgia, but there were no floods. The usual advices were issued.

Moderate to heavy rains fell over the drainage area of the upper Arkansas River about the middle of the month, and flood warnings were issued for all points from La Junta, Colo., to Mulvane, Kans. Flood stages were exceeded at Fort Lyon, Colo., and Dodge City, Kans., with crests of 8.6 feet, or 2.6 feet above flood stage, at Fort Lyon on the 22d, and of 5.8 feet, or 0.8 foot above flood stage, at Dodge City on the 24th.

Among the losses in Colorado was that of an irrigation reservoir dam on the Apishapa River, a tributary of the Arkansas, resulting in an estimated damage of $697,000, while the estimated value of property saved by the warnings was placed at $200,000. In Kansas the total losses amounted to $44,860, of which $28,500 was in crops, in hand and prospective. Erosion of abutting lands caused losses of about $10,000.

A destructive summer flood occurred near the middle of the month in northern Utah, and following will be found a report thereon, prepared by Mr. J. Cecil Alter, Meteorologist in Charge of the Weather Bureau Office at Salt Lake City, Utah:

FLOODS AT FARMINGTON AND WILLARD, UTAH.

Local thundershowers at dusk, Monday evening, August 13, 1923, along the west slope of the Wasatch Mountains in northern Utah, produced the most intense downpour of record in the Salt Lake City rain gage, with unusually heavy rains at a few other places near the foot of the mountains, and sent the most destructive floods of record in the State, consisting largely of earth and rocks, out of the steep canyons at Farmington and Willard, 16 and 50 miles, respectively, north of Salt Lake City. Nine human lives were destroyed, and the loss at Farmington and Willard is estimated at from $105,000 to $120,000.

The storm, which gathered slowly during the late afternoon without exceptional manifestations of wind, lightning, or other phenomena, occurred in connection with a shallow, circular LOW charted over southern Idaho and northern Utah that morning, but which formed an arm from southeastern Wyoming to a Mississippi valley LOW 24 hours later. The heavy rains were rather local, however, little or none falling over Great Salt Lake and the western part of the Salt Lake (City) valley, while stations in the Wasatch Mountains received less rain than stations along the base of the range.

Descending onto the business section of Salt Lake City, street elevation about 4,300 feet above the sea, at 6:38 p. m., new records for rainfall intensity were established as follows: In 5 minutes (6:53 to 6:58) 0.35 inch, 10 minutes 0.56 inch, 15 minutes 0.76 inch, 30 minutes 1.05 inches, 1 hour 1.17 inches, and 2 hours 1.23 inches, this being the total for the storm, and a new 24-hour record for August. In the minute ending at 6:55 p. m. 0.10 inch fell, this probably being a new record; sprinkles preceded and followed the rain for some time. At the University of Utah, 2 miles due east, elevation 4,500

feet, 0.80 inch fell, and at Mountain Dell, 11 miles east, elevation 5,500 feet, the storm amounted to 0.65 inch.

An automatic record was obtained at High Line, City Creek, 8 miles northeast, elevation 5,300 feet, on a Marvin float gage. As at Salt Lake City, the rain began very suddenly at 6:39 p. m., accumulating according to the tracing, 0.25 inch in 10 minutes, 0.67 inch in 20 minutes, 0.90 inch in 30 minutes, 0.94 inch in 40 minutes, 0.97 inch in 50 minutes, 1.01 inches in 1 hour, 1.12 inches in 1½ hours, and 1.15 inches for the storm. These amounts are exceptional, being unequaled for intensity in the short record available. The rain amounted to 1.34 inches at Farmington, elevation 4,267 feet, falling between 7:30 p. m. and 9 p. m.; while at Morgan, 12 miles east by northeast of Farmington, over the divide, elevation 5,080 feet, only 0.15 inch fell.

The rain began somewhat earlier over the Farmington watershed, evidently, as the flood crashed onto the town within 15 or 20 minutes after rain began in Farmington. Gathering flotsam and débris of a rather heavy nature, the flood waters were checked at intervals in the narrower parts of the channel, and thus an immense head of water was soon accumulated. Finally the moving dam and reservoir dashed through the winding but wider portion of the canyon, being the last 2 or 3 miles, with tremendous power and devastation.

A large wad of mud was contributed by Mud Creek, a branch from the north about 3 miles from the canyon outlet. Immediately below Mud Creek outlet a concrete intake dam and a few hundred feet of wood stave pipe line were swept away, the flood crest having already caught eight work horses almost from the hands of their drivers another mile up the main canyon.

Gaining destructiveness by the addition of rocks and trees caved from the creek bank, the flood evidently hit a tourist camp site, about 2 miles above the canyon outlet, without warning. Four Boy Scouts, Wilford I. Langton, George Jackson, and Ted and Vernon Rudy, and Mr. and Mrs. Walter J. Wright, were presumably settled there for the night, and their bodies, partly dismembered and horribly mangled, were found in the lower part of the canyon, or well outside, in the path of the flood.

The lower or last mile or so of the canyon was gored and scoured to great depths, and an incalculable tonnage of earth and rocks was evacuated far out into the valley through the north edge of Farmington town, which is about a mile from the outlet. About half of the brick electric plant, a mile within the canyon, was carried away, four houses at Farmington were badly damaged; and several streets, the State highway, and the Bamberger Electric Railroad were covered with mud for many rods.

Arnold Christensen overexhausted himself while rescuing his wife and children from the flood in which they were being carried, and died instantly of heart failure. Approximately 20 acres of land in crops were deeply overlaid with earth and bowlders and rendered useless for farming purposes, while about 125 acres were partially or temporarily damaged. Steed Canyon and two other arroyos south of Farmington discharged unusual volumes of earth and rocks, one of them covering a small acreage of land near Centerville. The total loss in the neighborhood of Farmington is probably around $30,000 or $35,000.

The Willard Canyon discharge was much greater and more destructive, though it is thought the precipitation was little, if any, heavier. The precipitation at Brigham City, elevation 4,310 feet, 7 miles north, was only 0.63 inch, while at Ogden, elevation, 4,310 feet, 15 miles south, it was 1.04 inches. Willard Canyon is very steep and stony, with an extended series of crooked narrows, and in this choked channel the débris-laden flood was dammed and held back sufficient to allow a great head of water to gather at intervals.

Thus on leaving the narrows this tremendous volume of water dashed through the lower mile of the canyon at great speed, digging up and carrying away an unmeasurable tonnage of sand, gravel, and bowlders. An iron pipe line about a foot in diameter and extending from the head of the narrows to the electric plant near town, a distance of nearly 2 miles, was demolished and carried away; while the electric plant, on a gently sloping surface in the flood path, was bombarded with bowlders, one of them weighing about 12 tons, and the entire east wall was destroyed.

A tongue of mud and rocks from 500 to 750 feet wide darted across the south edge of Willard town, situated about three-eighths of a mile from the canyon outlet, sweeping four residences completely away and damaging many others. Two women—Mrs. Agnes M. Ward and her mother-in-law, Mrs. Mary E. B. Ward—perished when one of the buildings collapsed, and several other persons narrowly escaped casualties.

This flooded strip, comprising approximately 100 acres, including several blocks of improved town property, is covered from 1 to 3 feet deep with earth and bowlders. Another tongue of mud and bowlders from the canyon outlet shot across the north edge of town, approximately along the old stream channel, covering about 55 acres. Probably 15 per cent of the land covered can not be salvaged for agricultural or residence purposes.

A number of barns, granaries, small outbuildings, and fences, together with much poultry and many small pigs, were completely or partially destroyed, and 15 residences were more or less damaged by having porches and annexes crushed or carried away, basements filled, and ground floors besmeared with mud, and the yards and orchards deeply covered with mud, gravel, and rocks. A considerable amount of farming machinery, several automobiles, and some harvested crops were also deeply covered or badly damaged. The total loss of land, crops, and improvements is estimated at $75,000 or $85,000, largely in electric-plant installations.

The Willard Canyon watershed is rather compact, precipitous, and rocky, probably covering around 15 or 18 square miles. It was being grazed by cattle, sheep, and horses. The stream channel was scoured to bedrock through several thousand feet, the exposed surfaces showing much watermarking, as if by previous floods, though hidden by sediment, rocks, and sand for untold years. Huge bowlders clogged in the sediment of previous floods, exposed but not carried away, also showed rounded corners, gained no doubt in previous floods, probably before the pioneers came to Utah in 1847. There is little or no forested land in the canyon.

The Farmington watershed is somewhat more extensive and is longer and less precipitous. Some cattle, horses, and sheep were grazing the area, and occasional grass and brush fires in past years have aided in preventing vegetation from setting densely. There is very little, if any, forest cover. The stream channel in the canyon was freshly eroded to bedrock in a few spots, these spots showing the abrasions of earlier floods.

Important floods have come out of both canyons since Utah was settled, and some of the evidences of previous flooding may have been produced at those times; but the belief of a number of examiners is that there were prehistoric floods of great extent. The inference is thus compelling that such floods might occur again under

similarly favorable conditions of the watershed or the downpour of rain. Since the canyons have been recently cleansed, particularly Willard Canyon, a heavy rain could not now carry out nearly so much débris.

There is unquestionably an important connection between these floods and the partial denudation of the ground cover of the watersheds by vegetation, fires, and livestock grazing. But without touching the question of lessening the flood danger by a simple reduction in the number of livestock grazed, it is worthy of mention that the heavy rain occurring in City Creek Canyon, which debouches near the business center of Salt Lake City, as shown by the Marvin float gage at the High Line, served to raise the stream only 0.27 foot, or about 3 inches. The watershed comprises about 25 or 30 square miles, much of it being rather steep; but it has not been grazed at all, nor extensively burned over, for about 20 years.

*Flood stages during August, 1923.*

| River and station. | Flood stage. | Above flood stages—dates. | | Crest. | |
|---|---|---|---|---|---|
| | | From— | To— | Stage. | Date. |
| ATLANTIC DRAINAGE. | | | | | |
| | *Feet.* | | | *Feet.* | |
| Santee: Rimini, S. C. | 12 | 31 | (1) | 12.9 | 31 |
| Saluda: Pelzer, S. C. | 7 | 29 | 29 | 11.9 | 29 |
| MISSISSIPPI DRAINAGE. | | | | | |
| Arkansas: | | | | | |
| Fort Lyon, Colo. | 6 | 18 | 18 | 8.0 | 18 |
| Do. | 6 | 22 | 22 | 8.6 | 22 |
| Dodge City, Kans. | 5 | 20 | 20 | 5.8 | 24 |
| Purgatoire: Higbee, Colo. | 4 | 22 | 22 | 4.8 | 22 |

[1] Continued into September.

## MEAN LAKE LEVELS DURING AUGUST, 1923.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., Sept. 5, 1923.]

The following data are reported in the "Notice to Mariners" of the above date:

| Data. | Lakes.[1] | | | |
|---|---|---|---|---|
| | Superior. | Michigan and Huron. | Erie. | Ontario. |
| Mean level during August, 1923: | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| Above mean sea level at New York | 602.06 | 579.76 | 571.70 | 245.41 |
| Above or below— | | | | |
| Mean stage of July, 1923 | +0.19 | −0.13 | −0.34 | −0.39 |
| Mean stage of August, 1922 | −0.53 | −0.83 | −0.80 | −1.15 |
| Average stage for August, last 10 years | −0.67 | −1.20 | −1.08 | −1.15 |
| Highest recorded August stage | −1.87 | −3.75 | −2.41 | −2.85 |
| Lowest recorded August stage | +0.46 | −0.09 | +0.32 | +1.06 |
| Average relation of the August level to— | | | | |
| July, level | ..... | −0.10 | −0.20 | −0.30 |
| September, level | ..... | +0.20 | +0.30 | +0.40 |

[1] Lake St. Clair's level: In August, 574.61 feet.

## EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, AUGUST, 1923.

By J. B. KINCER, Meteorologist.

The droughty conditions that obtained in the lower Great Plains from southern Kansas southward at the close of July were much intensified by continued absence of rain during the first three weeks of August. Hot and dry weather prevailed in that area resulting in a general and, in some cases, marked deterioration in growing crops. The drought was especially severe in Oklahoma, and scattered showers that were received in Texas and southern Kansas were mainly ineffective. The last week of the month brought relief, however, when heavy rains occurred in the driest portion of the area, and fairly well-distributed showers in most other sections. The rain came too late, however, for some crops in Oklahoma, but others, such as truck, late cotton, and sorghum, were materially benefited.

Winter wheat harvest was practically completed during the first half of the month, except in a few late districts, but there was considerable delay in threshing, because of wet weather, in the Ohio and upper Mississippi Valleys and in Nebraska. The cooler weather the first part of the month favored the filling of spring grains in central Rocky Mountain districts, while showers were beneficial in the central Plateau sections of the West. Threshing small grains advanced satisfactorily during the latter part of the month in the Northern States, but there was considerable damage to grain in shock by wet weather in some central valley districts.

Timely and beneficial showers, with good growing temperatures, gave very favorable conditions for corn during the first two decades of the month throughout the principal producing districts, except in the southern Great Plains and in northern Iowa where moisture was deficient. This crop was badly damaged by drought in Oklahoma and portions of the adjoining States. The latter part of the month, however, was much too cool for corn in the great central valleys, the Central-Northern and Northeastern States, and at its close the crop needed more sunshine and warmth generally. Conditions continued rather favorable, however, in the extreme lower Missouri Valley and much of the Central Plains area.

The month was generally unfavorable for cotton. The severe drought in the western portion of the belt caused general deterioration in Texas, while much complaint of wilting and shedding, with bolls opening prematurely, was received from Oklahoma. Rainfall was less frequent, however, in most of the eastern portions of the belt, particularly in southeastern localities, but there was little response of the crop to the more favorable conditions, while the latter part of the month again brought cloudy, showery, and unfavorable weather. The drought was broken in the western portion of the belt near the close of the month, and shedding and premature opening were checked, with a general improvement in condition in most sections.

There was sufficient rainfall to maintain pastures in good condition in all sections east of the Mississippi River, except that they were short in most places from the Lake region eastward. In many portions of New York the water supply was low, while it was much too dry in many other sections of the Northeastern States. Showers in the far Southwest materially improved the range, while the generous rains from the southern Plains southward the latter part of the month were of great benefit.

Fruit generally did well, though there was some frost damage to cranberries in Wisconsin the latter part of the month. Fruits were especially promising in the far West, and citrus developed well in both Florida and California, though rain was needed locally in parts of the former State.

## CLIMATOLOGICAL TABLES.[1]

### CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

*Condensed climatological summary of temperature and precipitation by sections, August, 1923.*

| Section. | Temperature. | | | | | | | | Precipitation. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Section average. | Departure from the normal. | Monthly extremes. | | | | | | Section average. | Departure from the normal. | Greatest monthly. | | Least monthly. | |
| | | | Station. | Highest. | Date. | Station. | Lowest. | Date. | | | Station. | Amount. | Station. | Amount. |
| | °F. | °F. | | °F. | | | °F. | | In. | In. | | In. | | In. |
| Alabama | 78.9 | −0.6 | Selma | 98 | 18 | 2 stations | 51 | [2] 24 | 6.28 | +1.56 | Citronelle | 10.96 | Tuskegee | 1.02 |
| Alaska | | | | | | | | | | | | | | |
| Arizona | 77.0 | −1.7 | Mohawk | 114 | [2] 28 | Fort Valley | 39 | 22 | 3.30 | +0.59 | Henry's Camp | 8.00 | Yuma Citrus Station | 0.06 |
| Arkansas | 81.9 | +2.5 | 2 stations | 109 | [2] 4 | Dutton | 49 | [2] 24 | 2.43 | −1.40 | Heber Springs | 7.68 | Fayetteville | 0.00 |
| California | 71.1 | −1.4 | Greenland Ranch | 119 | 28 | Fordyce Dam | 24 | 9 | 0.13 | +0.03 | West Branch | 2.55 | 93 stations | 0.00 |
| Colorado | 63.3 | −1.5 | Wray | 99 | [2] 11 | Longs Peak | 21 | 29 | 3.34 | +1.38 | Cuchara Camps | 10.09 | Rugh Ranch | 0.57 |
| Florida | 81.3 | 0.0 | New Smyrna | 102 | 14 | Davie | 63 | 16 | 6.73 | −0.56 | Garniers | 13.48 | Ft. Pierce | 1.09 |
| Georgia | 79.9 | +0.4 | 2 stations | 101 | 15 | Clayton | 50 | 16 | 5.63 | +0.11 | Milledgeville | 11.56 | Canton | 2.37 |
| Hawaii | 74.7 | +0.1 | Pahala | 92 | 17 | Waimea | 52 | 8 | 6.07 | −1.79 | Honomu | 26.06 | 5 stations | 0.00 |
| Idaho | 66.4 | −0.2 | Weiser | 110 | 12 | Stanley | 21 | 2 | 0.90 | +0.21 | Wallace | 2.33 | 2 stations | T. |
| Illinois | 74.0 | −0.1 | Henry | 103 | 11 | Ottawa | 38 | 26 | 4.89 | +1.57 | Sparta | 13.22 | Walnut | 1.51 |
| Indiana | 72.8 | −0.5 | 2 stations | 99 | [2] 11 | 2 stations | 38 | [2] 23 | 4.81 | +1.55 | Valparaiso | 10.93 | Angola | 2.12 |
| Iowa | 70.6 | −1.2 | Fairfiled | 102 | 11 | 3 stations | 38 | 22 | 5.42 | +1.74 | Grundy Center | 13.14 | Clinton | 1.46 |
| Kansas | 78.2 | +0.8 | Medicine Lodge | 113 | 14 | Atwood | 40 | 22 | 2.42 | −0.65 | Healy | 7.76 | Norwich | 0.00 |
| Kentucky | 75.5 | −0.2 | Lone Oak | 99 | 12 | 2 stations | 43 | 24 | 6.04 | +2.48 | Calhoun | 12.77 | Anchorage | 2.17 |
| Louisiana | 81.6 | 0.0 | 2 stations | 104 | 17 | 2 stations | 51 | [2] 24 | 5.59 | +0.36 | Reserve | 13.85 | Plain Dealing | 0.20 |
| Maryland-Delaware | 72.8 | −0.6 | 2 stations | 98 | [2] 7 | Grantsville, Md. | 34 | 23 | 3.08 | −1.34 | Princess Anne, Md. | 6.65 | Delaware City, Del. | 0.94 |
| Michigan | 64.4 | −1.9 | Charlotte | 99 | 1 | 2 stations | 29 | [2] 8 | 2.61 | −0.18 | Maple Ridge | 6.13 | Eagle Harbor | 0.55 |
| Minnesota | 64.9 | −1.9 | Pipestone | 95 | [2] 11 | Angus | 29 | 24 | 2.28 | −0.84 | New Ulm | 7.21 | Collegeville | 0.75 |
| Mississippi | 80.2 | −0.2 | 2 stations | 100 | 15 | Batesville | 53 | 24 | 5.52 | +1.07 | Biloxi | 11.53 | Rosedale | 0.57 |
| Missouri | 77.3 | +1.3 | Hollister | 108 | 14 | Unionville (2) | 42 | [2] 24 | 3.99 | +0.31 | St. Catharine | 9.55 | Neosho | 0.24 |
| Montana | 63.8 | −0.7 | Billings | 104 | 12 | 2 stations | 30 | [2] 1 | 1.69 | +0.50 | Red Lodge | 4.86 | Vananda | 0.30 |
| Nebraska | 71.0 | −1.8 | 2 stations | 101 | [2] 10 | Ainsworth | 35 | 22 | 4.76 | +1.95 | Wakefield | 11.41 | Harrisburg | 1.56 |
| Nevada | 69.3 | −1.5 | Beatty | 108 | [2] 17 | Rye Patch | 24 | 11 | 0.65 | +0.14 | Schurz | 2.92 | Mina | 0.02 |
| New England | 64.7 | −1.7 | Waterbury, Conn. | 99 | 4 | Berlin, N. H. | 32 | 24 | 2.19 | −1.63 | Storrs, Conn | 4.53 | Lewiston, Me. | 0.98 |
| New Jersey | 70.8 | −1.2 | Little Falls | 98 | 5 | Charlotte | 35 | 24 | 2.44 | −2.30 | Bridgeton | 4.81 | Little Falls | 1.23 |
| New Mexico | 69.3 | −0.9 | Orogrande | 110 | 1 | Elizabethtown | 31 | 28 | 3.78 | +1.73 | Des Moines | 10.17 | Artesia | 0.09 |
| New York | 66.1 | −1.2 | Willard | 97 | 3 | 2 stations | 29 | 24 | 2.08 | −1.78 | Hoffmeister | 4.96 | Lauterbrunnen | T. |
| North Carolina | 76.0 | +0.7 | Lumberton | 100 | 16 | Mount Mitchell | 42 | 24 | 4.49 | −1.12 | Elizabethtown | 11.74 | Marshall | 0.84 |
| North Dakota | 63.0 | −2.4 | Westhope | 97 | 31 | Hansboro | 28 | 24 | 1.90 | −0.38 | Bottineau | 4.98 | Beach | 0.24 |
| Ohio | 70.7 | −1.1 | Xenia | 98 | 12 | 2 stations | 34 | [2] 22 | 4.34 | +0.83 | Athens | 8.89 | Catawba Island | 1.64 |
| Oklahoma | 83.7 | +3.0 | 4 stations | 112 | [2] 1 | 4 stations | 49 | 23 | 1.54 | −1.55 | Union City | 4.04 | 2 stations | T. |
| Oregon | 67.3 | +1.5 | Echo | 109 | 16 | Lapine | 26 | 8 | 0.45 | −0.07 | Cascade Locks | 2.08 | 2 stations | T. |
| Pennsylvania | 69.2 | −0.8 | 3 stations | 96 | 7 | Clearfield | 30 | 25 | 3.10 | −1.41 | Phoenixville | 7.30 | Indiana | 0.59 |
| Porto Rico | 79.9 | +0.7 | Ponce | 99 | [2] 1 | Aibonito | 60 | [2] 26 | 5.15 | −2.20 | Mayaguez | 12.73 | Ensenada | 0.57 |
| South Carolina | 79.3 | +0.5 | Society Hill | 101 | 15 | Walhalla | 54 | 27 | 7.44 | +1.35 | Georgetown | 14.30 | Due West | 3.15 |
| South Dakota | 67.7 | −1.8 | Wagner | 99 | 13 | Castlewood | 31 | 22 | 3.55 | +0.82 | Vermilion | 8.85 | Watertown | 0.63 |
| Tennessee | 76.9 | +0.1 | 2 stations | 100 | [2] 13 | Rugby | 44 | 24 | 6.19 | +2.06 | Hohenwald | 11.62 | Rogersville | 1.75 |
| Texas | 83.8 | +1.2 | 2 stations | 112 | [2] 1 | 2 stations | 52 | [2] 18 | 2.31 | −0.29 | Port Arthur | 9.71 | 2 stations | 0.00 |
| Utah | 68.0 | −1.3 | St. George | 102 | [2] 3 | Winter Quarters | 30 | 28 | 1.29 | +0.20 | Escalante | 4.50 | Lemay | T. |
| Virginia | 73.5 | −0.7 | Danville | 99 | 7 | Burkes Garden | 38 | 25 | 4.70 | +0.68 | Williamsburg | 10.84 | Lexington | 1.89 |
| Washington | 67.5 | +1.9 | 2 stations | 108 | 16 | Paradise Inn | 32 | 7 | 1.05 | +0.35 | Headworks | 2.46 | Hanford | T. |
| West Virginia | 71.0 | −0.7 | Moorefield | 99 | 11 | Terra Alta | 33 | 23 | 4.39 | +0.52 | Pickens | 12.42 | Upper Tract | 1.60 |
| Wisconsin | 65.0 | −1.7 | Lake Mills | 98 | 1 | Long Lake | 28 | 25 | 2.79 | −0.42 | Manitowaoc | 5.78 | Danbury | 0.71 |
| Wyoming | 63.1 | −0.9 | Thermopolis | 102 | 11 | 2 stations | 26 | [2] 17 | 1.66 | +0.55 | Knowles | 7.17 | Green River | 0.05 |

[1] For description of tables and charts, see REVIEW, July, 1922, pp. 384-385.

[2] Other dates also.

TABLE I.—*Climatological data for Weather Bureau stations, August, 1923.*

| Districts and stations. | Elevation of instruments. | | | Pressure. | | | Temperature of the air. | | | | | | | | | | | Mean wet thermometer. | Mean temperature of the dew point. | Mean relative humidity. | Precipitation. | | | Wind. | | | | | | Clear days. | Partly cloudy days. | Cloudy days. | Average cloudiness, tenths. | Total snowfall. | Snow, sleet and ice on ground at end of month |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer above sea level. | Thermometer above ground. | Anemometer above ground. | Station, reduced to mean of 24 hours. | Sea level, reduced to mean of 24 hours. | Departure from normal. | Mean max. + mean min. ÷2. | Departure from normal. | Maximum. | Date. | Mean maximum. | Minimum. | Date. | Mean minimum. | Greatest daily range. | | | | | | Total. | Departure from normal. | Days with 0.01, or more. | Total movement. | Prevailing direction. | Maximum velocity. Miles per hour. | Maximum velocity. Direction. | Maximum velocity. Date. | | | | | | | |
| | *Ft.* | *Ft.* | *Ft.* | *In.* | *In.* | *In.* | *°F.* | *°F.* | *°F.* | | *°F* | *°F.* | | *°F.* | *°F.* | *°F.* | *°F.* | *°F.* | *°F.* | *%* | *In.* | *In.* | | *Miles.* | | | | | | | | | *0–10* | *In.* | *In.* |
| *New England.* | | | | | | | **65.6** | **−1.7** | | | | | | | | | | | | **78** | **1.93** | **−2.0** | | | | | | | | | | | **4.6** | | |
| Eastport | 76 | 67 | 85 | 29.86 | 29.94 | −.02 | 57.6 | −3.1 | 76 | 5 | 66 | 45 | 28 | 49 | 26 | 53 | 51 | 85 | 2.47 | −0.8 | 11 | 5,937 | s. | 32 | s. | 21 | 8 | 11 | 12 | 6.2 | 0.0 | 0.0 |
| Greenville, Me | 1,070 | 6 | .... | 28.79 | 29.95 | ..... | 59.2 | ..... | 81 | 3 | 70 | 36 | 24 | 49 | 32 | ..... | ..... | ..... | 2.85 | ..... | 13 | ..... | ..... | ..... | ..... | ..... | 13 | 6 | 12 | ..... | 0.0 | 0.0 |
| Portland, Me | 103 | 82 | 117 | 29.86 | 29.98 | .00 | 64.1 | −2.3 | 86 | 4 | 72 | 48 | 24 | 56 | 24 | 58 | 54 | 75 | 3.18 | −0.4 | 12 | 6,267 | s. | 33 | nw. | 22 | 15 | 10 | 6 | 4.2 | 0.0 | 0.0 |
| Concord | 288 | 70 | 79 | 29.66 | 29.96 | −.02 | 65.6 | −1.2 | 92 | 4 | 78 | 42 | 24 | 53 | 35 | ..... | ..... | ..... | 2.19 | −1.6 | 9 | 3,064 | s. | 24 | nw. | 13 | 18 | 11 | 2 | 3.2 | 0.0 | 0.0 |
| Burlington | 404 | 11 | 48 | 29.51 | 29.94 | −.03 | 64.8 | −1.3 | 87 | 7 | 76 | 40 | 24 | 53 | 32 | ..... | ..... | ..... | 2.29 | −1.7 | 10 | 7,002 | s. | 42 | sw. | 28 | 12 | 9 | 10 | 5.1 | 0.0 | 0.0 |
| Northfield | 876 | 12 | 60 | 29.03 | 29.97 | −.01 | 61.6 | −1.3 | 87 | 3 | 76 | 36 | 24 | 47 | 37 | 57 | 55 | 81 | 1.07 | −2.9 | 9 | 4,889 | s. | 32 | s. | 28 | 8 | 15 | 8 | 5.6 | 0.0 | 0.0 |
| Boston | 125 | 115 | 188 | 29.83 | 29.97 | −.02 | 69.4 | −0.5 | 94 | 4 | 78 | 51 | 24 | 61 | 25 | 62 | 58 | 72 | 1.86 | −2.2 | 7 | 6,800 | w. | 32 | sw. | 21 | 10 | 15 | 6 | 4.6 | 0.0 | 0.0 |
| Nantucket | 12 | 14 | 90 | 29.97 | 29.98 | −.01 | 65.4 | −2.6 | 78 | 10 | 72 | 51 | 17 | 58 | 20 | 61 | 59 | 85 | 1.90 | −1.2 | 5 | 9,924 | sw. | 46 | sw. | 22 | 14 | 6 | 11 | 5.0 | 0.0 | 0.0 |
| Block Island | 26 | 11 | 46 | 29.96 | 29.98 | −.01 | 66.4 | −2.1 | 80 | 15 | 72 | 53 | 23 | 60 | 17 | 62 | 60 | 86 | 1.10 | −2.4 | 3 | 9,729 | sw. | 38 | sw. | 22 | 14 | 9 | 8 | 4.5 | 0.0 | 0.0 |
| Providence | 160 | 215 | 251 | 29.81 | 29.98 | −.01 | 68.2 | −2.8 | 90 | 4 | 78 | 50 | 23 | 59 | 25 | 61 | 57 | 71 | 1.48 | −2.6 | 6 | 7,764 | s. | 48 | w. | 13 | 15 | 12 | 4 | 3.9 | 0.0 | 0.0 |
| Hartford | 159 | 122 | 140 | 29.80 | 29.97 | −.02 | 69.4 | +0.5 | 92 | 4 | 80 | 46 | 24 | 58 | 30 | 62 | 58 | 72 | 2.57 | −2.0 | 6 | 5,114 | s. | 31 | sw. | 21 | 11 | 12 | 8 | 4.7 | 0.0 | 0.0 |
| New Haven | 106 | 74 | 153 | 29.87 | 29.98 | −.01 | 68.6 | −1.7 | 91 | 5 | 77 | 48 | 23 | 60 | 24 | 62 | 59 | 72 | 1.17 | −3.8 | 6 | 6,037 | s. | 31 | sw. | 21 | 18 | 5 | 8 | 3.7 | 0.0 | 0.0 |
| *Middle Atlantic States.* | | | | | | | **72.3** | **−0.9** | | | | | | | | | | | | **77** | **2.86** | **−1.6** | | | | | | | | | | | **5.0** | | |
| Albany | 97 | 102 | 115 | 29.86 | 29.96 | −.02 | 69.2 | −1.6 | 93 | 5 | 80 | 45 | 24 | 58 | 30 | 61 | 56 | 68 | 2.21 | −1.8 | 7 | 5,055 | s. | 30 | s. | 21 | 17 | 12 | 2 | 3.1 | 0.0 | 0.0 |
| Binghamton | 871 | 10 | 84 | 29.05 | 29.97 | −.02 | 67.0 | −0.5 | 91 | 6 | 80 | 43 | 23 | 54 | 38 | ..... | ..... | ..... | 2.19 | −1.2 | 5 | 3,635 | nw. | 28 | sw. | 21 | 9 | 14 | 8 | 5.2 | 0.0 | 0.0 |
| New York | 314 | 414 | 454 | 29.65 | 29.98 | −.02 | 71.3 | −1.8 | 89 | 5 | 79 | 53 | 22 | 64 | 25 | 63 | 60 | 73 | 1.12 | −3.4 | 7 | 10,261 | s. | 58 | nw. | 22 | 14 | 11 | 6 | 4.9 | 0.0 | 0.0 |
| Harrisburg | 374 | 94 | 104 | 29.60 | 30.00 | −.01 | 71.8 | −0.3 | 92 | 7 | 81 | 49 | 24 | 63 | 28 | 64 | 60 | 71 | 0.73 | −3.5 | 8 | 3,710 | sw. | 26 | sw. | 28 | 12 | 8 | 11 | 5.4 | 0.0 | 0.0 |
| Philadelphia | 114 | 123 | 190 | 29.87 | 29.99 | −.01 | 73.8 | −1.0 | 91 | 7 | 82 | 55 | 23 | 66 | 24 | 65 | 61 | 70 | 4.26 | −0.4 | 10 | 6,269 | sw. | 29 | n. | 22 | 11 | 10 | 10 | 5.3 | 0.0 | 0.0 |
| Reading | 325 | 81 | 98 | 29.64 | 29.98 | ..... | 72.5 | ..... | 92 | 7 | 82 | 48 | 23 | 63 | 30 | 66 | 62 | 75 | 1.27 | −3.2 | 8 | 3,447 | se. | 25 | n. | 22 | 10 | 17 | 4 | 5.0 | 0.0 | 0.0 |
| Scranton | 805 | 111 | 119 | 29.14 | 29.99 | −.01 | 68.4 | −0.9 | 91 | 7 | 80 | 45 | 24 | 57 | 33 | 62 | 59 | 76 | 3.32 | −0.9 | 8 | 4,056 | s. | 28 | s. | 21 | 10 | 16 | 5 | 5.0 | 0.0 | 0.0 |
| Atlantic City | 52 | 37 | 172 | 29.93 | 29.98 | −.02 | 71.6 | −0.9 | 91 | 8 | 77 | 55 | 23 | 66 | 20 | 67 | 64 | 80 | 1.27 | −3.0 | 8 | 10,702 | s. | 44 | nw. | 22 | 14 | 11 | 6 | 4.4 | 0.0 | 0.0 |
| Cape May | 17 | 13 | 49 | 30.00 | 30.02 | +.02 | 72.8 | −0.6 | 93 | 8 | 80 | 51 | 23 | 66 | 22 | 68 | 66 | 85 | 4.02 | −0.2 | 13 | 5,231 | s. | 24 | sw. | 21 | 15 | 6 | 10 | 4.6 | 0.0 | 0.0 |
| Sandy Hook | 22 | 10 | 55 | 29.96 | 29.98 | ..... | 71.4 | ..... | ..... | 88 | 4 | 78 | 56 | 23 | 65 | 22 | 65 | 62 | 77 | 1.96 | ..... | 6 | 9,584 | s. | 44 | nw. | 22 | 15 | 12 | 4 | 3.9 | 0.0 | 0.0 |
| Trenton | 190 | 159 | 183 | 29.78 | 29.98 | ..... | 71.6 | ..... | 90 | 4 | 81 | 48 | 23 | 62 | 26 | 64 | 61 | 74 | 3.32 | −2.0 | 8 | 6,777 | sw. | 35 | nw. | 22 | 11 | 8 | 12 | 5.5 | 0.0 | 0.0 |
| Baltimore | 123 | 100 | 113 | 29.85 | 29.98 | −.03 | 74.8 | −0.7 | 96 | 8 | 83 | 55 | 23 | 66 | 25 | 67 | 63 | 72 | 3.14 | −1.1 | 10 | 3,957 | s. | 22 | sw. | 21 | 8 | 12 | 11 | 5.6 | 0.0 | 0.0 |
| Washington | 112 | 62 | 85 | 29.87 | 29.99 | −.02 | 74.4 | −0.6 | 94 | 3 | 84 | 51 | 22 | 65 | 28 | 68 | 65 | 78 | 2.19 | −2.2 | 11 | 3,531 | sw. | 28 | nw. | 12 | 10 | 11 | 10 | 5.5 | 0.0 | 0.0 |
| Lynchburg | 681 | 153 | 188 | 29.27 | 30.00 | −.02 | 74.8 | −0.8 | 94 | 8 | 84 | 49 | 24 | 65 | 29 | 67 | 65 | 78 | 3.44 | −0.8 | 13 | 4,182 | w. | 34 | n. | 8 | 11 | 13 | 7 | 4.8 | 0.0 | 0.0 |
| Norfolk | 91 | 170 | 205 | 29.91 | 30.00 | .00 | 77.4 | 0.0 | 92 | 8 | 85 | 59 | 23 | 70 | 22 | 71 | 69 | 83 | 4.47 | −1.5 | 13 | 7,736 | s. | 41 | nw. | 11 | 6 | 13 | 12 | 6.1 | 0.0 | 0.0 |
| Richmond | 144 | 11 | 52 | 29.84 | 29.99 | −.02 | 75.2 | −2.3 | 94 | 15 | 84 | 49 | 22 | 66 | 31 | 69 | 67 | 82 | 6.41 | +2.0 | 12 | 4,660 | sw. | 33 | sw. | 5 | 9 | 11 | 11 | 5.7 | 0.0 | 0.0 |
| Wytheville | 2,304 | 49 | 56 | 27.70 | 30.01 | .00 | 70.0 | −0.5 | 87 | 6 | 79 | 48 | 25 | 61 | 30 | 64 | 63 | 85 | 2.39 | −2.2 | 14 | 3,280 | w. | 19 | w. | 21 | 13 | 14 | 4 | 4.6 | 0.0 | 0.0 |
| *South Atlantic States.* | | | | | | | **79.2** | **+0.9** | | | | | | | | | | | | **83** | **5.20** | **−0.9** | | | | | | | | | | | **6.0** | | |
| Asheville | 2,255 | 70 | 84 | 27.74 | 30.02 | .00 | 72.6 | +2.1 | 88 | 21 | 82 | 51 | 25 | 63 | 28 | 66 | 64 | 85 | 2.75 | −1.8 | 12 | 3,642 | nw. | 27 | nw. | 5 | 10 | 19 | 2 | 4.5 | 0.0 | 0.0 |
| Charlotte | 779 | 55 | 62 | 29.19 | 30.01 | −.01 | 78.4 | +1.3 | 97 | 15 | 88 | 56 | 23 | 69 | 27 | 70 | 67 | 78 | 2.93 | −2.6 | 10 | 2,402 | sw. | 17 | nw. | 22 | 5 | 14 | 12 | 6.5 | 0.0 | 0.0 |
| Hatteras | 11 | 11 | 50 | 29.99 | 30.00 | .00 | 78.5 | +0.5 | 89 | 13 | 84 | 66 | 24 | 74 | 14 | 74 | 73 | 85 | 5.02 | −0.8 | 10 | 8,721 | sw. | 56 | nw. | 22 | 9 | 14 | 8 | 5.4 | 0.0 | 0.0 |
| Manteo | 12 | 5 | 42 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Raleigh | 376 | 103 | 110 | 29.61 | 30.00 | −.01 | 77.4 | +0.6 | 96 | 15 | 86 | 56 | 23 | 68 | 34 | 71 | 69 | 83 | 3.88 | −2.0 | 12 | 4,702 | sw. | 31 | n. | 22 | 5 | 13 | 13 | 6.6 | 0.0 | 0.0 |
| Wilmington | 78 | 81 | 91 | 29.94 | 30.02 | +.02 | 79.2 | +1.6 | 93 | 7 | 86 | 62 | 24 | 72 | 19 | 74 | 73 | 87 | 5.04 | −1.5 | 20 | 4,541 | sw. | 34 | ne. | 30 | 9 | 12 | 10 | 5.5 | 0.0 | 0.0 |
| Charleston | 48 | 11 | 92 | 29.98 | 30.03 | +.02 | 81.8 | +0.8 | 96 | 12 | 88 | 70 | 25 | 75 | 22 | 75 | 73 | 82 | 12.29 | +5.3 | 18 | 6,501 | sw. | 32 | ne. | 30 | 5 | 13 | 13 | 6.7 | 0.0 | 0.0 |
| Columbia, S. C | 351 | 41 | 57 | 29.65 | 30.02 | +.01 | 80.0 | +0.5 | 98 | 15 | 89 | 62 | 24 | 71 | 24 | 72 | 71 | 84 | 5.47 | −1.3 | 18 | 3,929 | sw. | 24 | w. | 28 | 4 | 13 | 14 | 6.6 | 0.0 | 0.0 |
| Due West | 711 | 10 | 55 | 29.28 | 30.04 | ..... | 78.1 | ..... | 96 | 15 | 88 | 58 | 25 | 68 | 28 | ..... | ..... | ..... | 3.15 | ..... | 10 | 4,726 | sw. | 36 | sw. | 17 | 0 | 20 | 11 | 6.5 | 0.0 | 0.0 |
| Greenville, S. C | 1,039 | 113 | 122 | 28.93 | 30.00 | ..... | 76.7 | ..... | 93 | 16 | 85 | 59 | 24 | 68 | 23 | 70 | 68 | 82 | 11.17 | ..... | 13 | 4,516 | sw. | 39 | nw. | 28 | 8 | 15 | 8 | 5.4 | 0.0 | 0.0 |
| Augusta | 180 | 62 | 77 | 29.82 | 30.01 | .00 | 80.8 | +0.4 | 96 | 14 | 89 | 67 | 24 | 73 | 22 | 73 | 71 | 80 | 3.36 | −2.2 | 13 | 2,928 | s. | 19 | nw. | 17 | 4 | 15 | 12 | 6.8 | 0.0 | 0.0 |
| Savannah | 65 | 150 | 194 | 29.96 | 30.03 | +.02 | 81.9 | +1.2 | 96 | 13 | 91 | 68 | 30 | 73 | 23 | 74 | 72 | 82 | 6.60 | −0.9 | 12 | 7,249 | sw. | 37 | nw. | 30 | 6 | 16 | 9 | 5.9 | 0.0 | 0.0 |
| Jacksonville | 43 | 209 | 245 | 30.00 | 30.05 | +.04 | 81.9 | +0.2 | 94 | 7 | 90 | 70 | 30 | 74 | 23 | 74 | 72 | 80 | 4.67 | −1.5 | 16 | 7,290 | sw. | 48 | sw. | 27 | 7 | 14 | 10 | 6.0 | 0.0 | 0.0 |
| *Florida Peninsula.* | | | | | | | **82.1** | **−0.2** | | | | | | | | | | | | **77** | **5.25** | **−1.7** | | | | | | | | | | | **5.0** | | |
| Key West | 22 | 10 | 64 | 30.01 | 30.03 | +.05 | 82.7 | −0.8 | 90 | 1 | 88 | 71 | 21 | 77 | 15 | 76 | 73 | 75 | 3.88 | −0.8 | 11 | 6,131 | se. | 38 | se. | 6 | 13 | 12 | 6 | 4.5 | 0.0 | 0.0 |
| Miami | 25 | 71 | 79 | 30.04 | 30.07 | ..... | 81.6 | −0.4 | 89 | 13 | 87 | 71 | 13 | 76 | 18 | 75 | 73 | 75 | 6.34 | −1.3 | 13 | 4,817 | e. | 24 | e. | 11 | 12 | 10 | 9 | 4.9 | 0.0 | 0.0 |
| Sand Key | 23 | 39 | 72 | 30.02 | 30.06 | +.08 | 81.1 | ..... | 86 | 3 | 84 | 70 | 6 | 78 | 13 | 76 | 74 | 76 | 3.43 | ..... | 10 | 8,430 | e. | 35 | se. | 7 | 12 | 14 | 5 | 4.6 | 0.0 | 0.0 |
| Tampa | 35 | 79 | 87 | 30.02 | 30.05 | +.05 | 81.9 | +0.5 | 93 | 28 | 89 | 71 | 31 | 74 | 19 | 75 | 74 | 83 | 5.52 | −3.1 | 16 | 3,375 | e. | 28 | se. | 20 | 3 | 17 | 11 | 6.1 | 0.0 | 0.0 |
| *East Gulf States.* | | | | | | | **79.4** | **−0.2** | | | | | | | | | | | | **84** | **5.68** | **+0.8** | | | | | | | | | | | **6.2** | | |
| Atlanta | 1,174 | 190 | 216 | 28.81 | 30.03 | +.02 | 77.4 | +0.4 | 94 | 15 | 86 | 64 | 26 | 69 | 22 | 72 | 70 | 84 | 4.17 | −0.3 | 14 | 6,021 | w. | 29 | w. | 6 | 6 | 9 | 16 | 6.4 | 0.0 | 0.0 |
| Macon | 370 | 78 | 87 | 29.63 | 30.02 | +.01 | 80.3 | +2.1 | 96 | 15 | 89 | 68 | 1 | 72 | 23 | 73 | 71 | 81 | 6.39 | +2.2 | 9 | 3,648 | sw. | 21 | nw. | 8 | 4 | 11 | 16 | 6.9 | 0.0 | 0.0 |
| Thomasville | 273 | 49 | 58 | 29.75 | 30.04 | +.04 | 79.9 | −1.1 | 94 | 20 | 89 | 67 | 31 | 71 | 23 | 74 | 72 | 84 | 6.89 | +1.9 | 19 | 2,607 | sw. | 18 | sw. | 23 | 4 | 15 | 12 | 6.7 | 0.0 | 0.0 |
| Apalachicola | 36 | 42 | 49 | 30.00 | 30.04 | ..... | 80.4 | ..... | 90 | 12 | 85 | 72 | 22 | 75 | 14 | 75 | 74 | 82 | 5.62 | ..... | 12 | 4,177 | s. | 19 | w. | 14 | 14 | 12 | 5 | 4.2 | 0.0 | 0.0 |
| Pensacola | 56 | 149 | 185 | 29.97 | 30.03 | +.05 | 78.8 | −2.1 | 88 | 11 | 84 | 69 | 1 | 74 | 15 | 75 | 74 | 85 | 9.59 | +2.4 | 16 | 7,027 | sw. | 40 | s. | 14 | 3 | 15 | 13 | 6.8 | 0.0 | 0.0 |
| Anniston | 741 | 9 | 57 | 29.27 | 30.05 | +.06 | 77.8 | +1.4 | 94 | 15 | 87 | 56 | 25 | 68 | 29 | ..... | ..... | ..... | 4.01 | −0.5 | 16 | 2,273 | sw. | 23 | nw. | 16 | 10 | 10 | 11 | 5.7 | 0.0 | 0.0 |
| Birmingham | 700 | 11 | 48 | 29.29 | 30.04 | +.05 | 78.4 | −1.4 | 95 | 15 | 87 | 58 | 25 | 70 | 28 | 71 | 70 | 83 | 6.90 | +2.4 | 16 | 3,279 | s. | 21 | nw. | 19 | 8 | 14 | 9 | 5.6 | 0.0 | 0.0 |
| Mobile | 57 | 125 | 161 | 29.96 | 30.02 | +.04 | 80.6 | +0.1 | 91 | 16 | 87 | 70 | 31 | 74 | 20 | 75 | 74 | 88 | 4.46 | −2.4 | 16 | 5,117 | sw. | 28 | nw. | 14 | 4 | 18 | 9 | 6.6 | 0.0 | 0.0 |
| Montgomery | 223 | 100 | 112 | 29.79 | 30.03 | +.04 | 79.8 | −1.0 | 92 | 18 | 88 | 67 | 25 | 72 | 22 | 73 | 72 | 84 | 6.30 | +2.1 | 11 | 3,635 | sw. | 36 | nw. | 13 | 3 | 13 | 15 | 6.8 | 0.0 | 0.0 |
| Corinth | 469 | 6 | ..... | ..... | ..... | ..... | 79.6 | ..... | 98 | 15 | 90 | 55 | 24 | 70 | 33 | ..... | ..... | ..... | 3.96 | ..... | 8 | ..... | se. | ..... | ..... | ..... | 5 | 21 | 5 | ..... | 0.0 | 0.0 |
| Meridian | 375 | 85 | 93 | 29.62 | 30.01 | +.03 | 78.9 | +0.4 | 93 | 15 | 87 | 60 | 26 | 70 | 26 | 73 | 71 | 83 | 4.49 | +0.9 | 13 | 3,063 | sw. | 33 | e. | 15 | 7 | 19 | 5 | 5.6 | 0.0 | 0.0 |
| Vicksburg | 247 | 65 | 73 | 29.75 | 30.02 | +.04 | 80.0 | −0.8 | 95 | 16 | 88 | 61 | 25 | 72 | 25 | 74 | 72 | 83 | 1.68 | −1.8 | 8 | 3,651 | sw. | 17 | sw. | 28 | 7 | 12 | 12 | 6.2 | 0.0 | 0.0 |
| New Orleans | 53 | 76 | 84 | 29.96 | 30.01 | +.03 | 82.0 | −0.2 | 93 | 17 | 89 | 70 | 6 | 75 | 19 | 76 | 74 | 83 | 7.60 | +2.0 | 16 | 3,592 | sw. | 23 | n. | 19 | 2 | 20 | 9 | 6.5 | 0.0 | 0.0 |
| *West Gulf States.* | | | | | | | **83.2** | **+2.0** | | | | | | | | | | | | **72** | **2.22** | **−0.7** | | | | | | | | | | | **4.0** | | |
| Shreveport | 249 | 77 | 93 | 29.72 | 29.98 | +.01 | 83.0 | +1.6 | 100 | 17 | 92 | 61 | 24 | 74 | 28 | 73 | 70 | 72 | 2.03 | −0.2 | 3 | 4,472 | se. | 18 | e. | 18 | 21 | 6 | 4 | 3.4 | 0.0 | 0.0 |
| Bentonville | 1,303 | 11 | 44 | ..... | ..... | ..... | 80.8 | +4.3 | 104 | 14 | 93 | 55 | 24 | 68 | 35 | ..... | ..... | ..... | 0.71 | ..... | 3 | ..... | ..... | ..... | ..... | ..... | 17 | 11 | 3 | ..... | 0.0 | 0.0 |
| Fort Smith | 457 | 79 | 94 | 29.47 | 29.94 | −.03 | 84.6 | +5.2 | 107 | 4 | 96 | 62 | 24 | 73 | 29 | 71 | 66 | 61 | 0.29 | −3.4 | 3 | 4,512 | e. | 25 | se. | 5 | 14 | 13 | 4 | 4.1 | 0.0 | 0.0 |
| Little Rock | 357 | 136 | 144 | 29.60 | 29.97 | −.01 | 81.5 | +1.7 | 98 | 17 | 91 | 61 | 24 | 72 | 29 | 73 | 70 | 77 | 2.55 | −1.1 | 8 | 4,774 | s. | 50 | nw. | 17 | 16 | 8 | 7 | 4.2 | 0.0 | 0.0 |
| Brownsville | 57 | 53 | 61 | 29.88 | 29.94 | ..... | 84.4 | ..... | 95 | 24 | 92 | 74 | 30 | 77 | 20 | 75 | 73 | 78 | 1.34 | ..... | 8 | 6,436 | s. | 28 | s. | 27 | 19 | 12 | 0 | 2.8 | 0.0 | 0.0 |
| Corpus Christi | 20 | 11 | 73 | 29.95 | 29.97 | +.04 | 83.4 | +1.3 | 93 | 23 | 90 | 72 | 28 | 77 | 17 | 77 | 75 | 82 | 2.64 | +0.4 | 5 | 9,590 | s. | 34 | s. | 27 | 15 | 13 | 3 | 3.6 | 0.0 | 0.0 |
| Dallas | 512 | 109 | 117 | 29.43 | 29.96 | ..... | 85.4 | ..... | 104 | 1 | 95 | 67 | 24 | 76 | 29 | ..... | ..... | ..... | 0.97 | ..... | 6 | 5,085 | s. | 26 | s. | 17 | 20 | 8 | 3 | 3.6 | 0.0 | 0.0 |
| Fort Worth | 670 | 106 | 114 | 29.24 | 29.93 | −.01 | 85.2 | +2.3 | 104 | 1 | 96 | 67 | 24 | 75 | 25 | 70 | 63 | 55 | 1.68 | −0.2 | 4 | 6,239 | se. | 28 | e. | 31 | 17 | 12 | 2 | 3.6 | 0.0 | 0.0 |
| Galveston | 54 | 106 | 114 | 29.95 | 30.01 | +.05 | 82.4 | −0.6 | 92 | 23 | 87 | 71 | 29 | 78 | 20 | 76 | 74 | 80 | 4.61 | −0.4 | 9 | 6,974 | s. | 32 | w. | 29 | 8 | 19 | 4 | 4.5 | 0.0 | 0.0 |
| Groesbeck | 461 | 11 | 56 | 29.50 | 29.97 | ..... | 84.3 | ..... | 102 | 3 | 96 | 64 | 26 | 73 | 30 | ..... | ..... | ..... | 2.13 | ..... | 3 | 7,012 | s. | 36 | sw. | 19 | 15 | 13 | 3 | 3.8 | 0.0 | 0.0 |
| Houston | 138 | 111 | 121 | 29.85 | 29.99 | ..... | 83.2 | +0.3 | 98 | 18 | 92 | 68 | 26 | 74 | 26 | ..... | ..... | ..... | 3.82 | ..... | 15 | 4,585 | s. | 28 | e. | 18 | 14 | 13 | 4 | 4.5 | 0.0 | 0.0 |
| Palestine | 510 | 64 | 72 | 29.46 | 29.98 | +.01 | 83.2 | +1.4 | 101 | 17 | 94 | 64 | 24 | 73 | 27 | 72 | 67 | 67 | 1.83 | −0.4 | 5 | 4,933 | s. | 26 | nw. | 30 | 10 | 17 | 4 | 4.7 | 0.0 | 0.0 |
| Port Arthur | 34 | 58 | 66 | 29.95 | 29.99 | ..... | 82.4 | ..... | 94 | 23 | 89 | 65 | 26 | 75 | 23 | 75 | 73 | 80 | 9.71 | ..... | 10 | 5,669 | s. | 32 | ne. | 18 | 10 | 16 | 5 | 4.8 | 0.0 | 0.0 |
| San Antonio | 693 | 119 | 132 | 29.24 | 29.95 | +.02 | 84.2 | +2.2 | 99 | 2 | 95 | 69 | 9 | 74 | 26 | 72 | 68 | 67 | 2.94 | +0.2 | 3 | 5,271 | se. | 31 | w. | 27 | 15 | 15 | 1 | 3.7 | 0.0 | 0.0 |
| Taylor | 583 | 55 | 63 | 29.40 | 30.01 | +.06 | 84.0 | +2.3 | 100 | 3 | 95 | 67 | 25 | 73 | 27 | ..... | ..... | ..... | 1.38 | −1.1 | 5 | 5,951 | s. | 31 | sw. | 27 | 12 | 17 | 2 | 4.3 | 0.0 | 0.0 |

TABLE I.—*Climatological data for Weather Bureau stations, August, 1923*—Continued.

| Districts and stations. | Elevation of instruments. | | | Pressure. | | | Temperature of the air. | | | | | | | | | Mean wet thermometer. | Mean temperature of the dew point. | Mean relative humidity. | Precipitation | | | Wind. | | | | | Clear days. | Partly cloudy days. | Cloudy days. | Average cloudiness, tenths. | Total snowfall. | Snow, sleet and ice on ground at end of month. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer above sea level. | Thermometer above ground. | Anemometer above ground. | Station, reduced to mean of 24 hours. | Sea level, reduced to mean of 24 hours. | Departure from normal. | Mean max. + mean min. ÷2. | Departure from normal. | Maximum. | Date. | Mean maximum. | Minimum. | Date. | Mean minimum. | Greatest daily range. | | | | Total. | Departure from normal. | Days with 0.01, or more. | Total movement. | Prevailing direction. | Maximum velocity. Miles per hour. | Maximum velocity. Direction. | Maximum velocity. Date. | | | | | | |
| *Ohio Valley and Tennessee.* | *Ft.* | *Ft.* | *Ft.* | *In.* | *In.* | *In.* | °F. | °F. | °F. | | °F. | °F. | | °F. | °F. | °F. | °F. | % | *In.* | *In.* | | *Miles.* | | | | | | | | *0–10* | *In.* | *In.* |
| | | | | | | | 74.6 | −0.3 | | | | | | | | | | 76 | 4.39 | +1.0 | | | | | | | | | | 3.4 | | |
| Chattanooga | 762 | 189 | 213 | 29.22 | 30.01 | +.01 | 77.4 | −0.1 | 93 | 16 | 86 | 58 | 25 | 69 | 25 | 70 | 67 | 78 | 2.94 | −0.8 | 10 | 3,788 | sw. | 33 | nw. | 16 | 6 | 22 | 3 | 5.3 | 0.0 | 0.0 |
| Knoxville | 996 | 102 | 111 | 28.98 | 30.01 | .00 | 76.2 | 0.0 | 92 | 8 | 86 | 54 | 25 | 67 | 27 | 69 | 66 | 79 | 2.97 | −1.0 | 8 | 3,468 | sw. | 30 | sw. | 21 | 7 | 12 | 12 | 6.1 | 0.0 | 0.0 |
| Memphis | 399 | 76 | 97 | 29.57 | 29.99 | +.01 | 80.5 | +1.0 | 94 | 17 | 88 | 59 | 24 | 73 | 22 | 73 | 71 | 77 | 5.06 | +1.9 | 9 | 4,764 | sw. | 32 | nw. | 9 | 11 | 15 | 5 | 4.1 | 0.0 | 0.0 |
| Nashville | 546 | 168 | 191 | 29.45 | 30.02 | +.02 | 76.4 | −1.4 | 94 | 15 | 86 | 54 | 24 | 67 | 27 | 70 | 68 | 80 | 9.60 | +6.1 | 14 | 4,213 | sw. | 38 | se. | 6 | 7 | 11 | 13 | 5.7 | 0.0 | 0.0 |
| Lexington | 989 | 193 | 230 | 28.96 | 30.01 | .00 | 74.4 | −0.2 | 90 | 11 | 83 | 51 | 22 | 66 | 22 | ..... | ..... | ..... | 4.02 | +0.4 | 13 | 6,769 | sw. | 36 | nw. | 26 | 9 | 13 | 9 | 5.3 | 0.0 | 0.0 |
| Louisville | 525 | 219 | 255 | 29.43 | 30.01 | +.01 | 76.4 | −0.6 | 94 | 12 | 86 | 52 | 23 | 67 | 28 | 68 | 65 | 73 | 2.29 | −1.2 | 11 | 5,611 | s. | 58 | nw. | 12 | 12 | 10 | 9 | 4.7 | 0.0 | 0.0 |
| Evansville | 431 | 139 | 175 | 29.54 | 30.00 | +.01 | 78.4 | +1.4 | 96 | 7 | 88 | 52 | 23 | 69 | 25 | 70 | 67 | 73 | 3.09 | −0.2 | 14 | 5,621 | sw. | 34 | se. | 20 | 4 | 25 | 2 | 5.6 | 0.0 | 0.0 |
| Indianapolis | 822 | 194 | 230 | 29.13 | 30.00 | .00 | 73.2 | −0.5 | 92 | 11 | 83 | 49 | 22 | 64 | 28 | 65 | 62 | 73 | 4.83 | +1.5 | 13 | 6,438 | sw. | 52 | w. | 12 | 9 | 14 | 8 | 5.3 | 0.0 | 0.0 |
| Royal Center | 736 | 11 | 55 | 29.21 | 29.99 | ..... | 68.8 | ..... | 91 | 11 | 80 | 41 | 23 | 58 | 32 | ..... | ..... | ..... | 4.04 | ..... | 11 | 5,090 | sw. | 37 | s. | 4 | 4 | 11 | 16 | 6.7 | 0.0 | 0.0 |
| Terre Haute | 575 | 96 | 129 | 29.38 | 29.98 | ..... | 74.5 | ..... | 93 | 11 | 84 | 50 | 23 | 65 | 28 | 67 | 64 | 76 | 6.91 | ..... | 11 | 5,167 | sw. | 48 | w. | 4 | 4 | 21 | 6 | 5.6 | 0.0 | 0.0 |
| Cincinnati | 628 | 11 | 51 | 29.33 | 29.99 | −.02 | 74.0 | +0.4 | 95 | 12 | 85 | 46 | 23 | 63 | 35 | .... | 65 | 78 | 3.72 | +0.4 | 12 | 3,784 | sw. | 36 | nw. | 12 | 12 | 11 | 8 | 5.1 | 0.0 | 0.0 |
| Columbus | 824 | 179 | 222 | 29.14 | 30.00 | −.01 | 71.8 | −1.2 | 90 | 12 | 81 | 48 | 23 | 63 | 31 | 64 | 60 | 72 | 4.97 | +1.8 | 15 | 5,405 | n. | 56 | w. | 12 | 11 | 8 | 12 | 5.4 | 0.0 | 0.0 |
| Dayton | 899 | 137 | 173 | 29.05 | 29.98 | ..... | 72.8 | −0.8 | 91 | 12 | 83 | 46 | 23 | 63 | 32 | 65 | 61 | 71 | 3.23 | +0.2 | 15 | 4,905 | sw. | 42 | nw. | 12 | 13 | 15 | 3 | 4.0 | 0.0 | 0.0 |
| Elkins | 1,947 | 59 | 67 | 28.02 | 30.01 | −.01 | 68.9 | +0.5 | 86 | 8 | 80 | 43 | 24 | 58 | 32 | 63 | 61 | 87 | 3.08 | −0.6 | 13 | 2,727 | w. | 29 | w. | 28 | 5 | 18 | 8 | 6.0 | 0.0 | 0.0 |
| Parkersburg | 638 | 77 | 84 | 29.36 | 30.01 | .00 | 73.0 | −0.3 | 90 | 7 | 83 | 48 | 24 | 63 | 31 | 66 | 63 | 79 | 7.38 | +3.8 | 14 | 2,729 | se. | 28 | nw. | 3 | 13 | 7 | 11 | 5.5 | 0.0 | 0.0 |
| Pittsburgh | 842 | 353 | 410 | 29.10 | 29.99 | −.02 | 71.0 | −1.9 | 90 | 7 | 80 | 46 | 23 | 62 | 25 | 63 | 60 | 72 | 4.24 | +1.1 | 12 | 5,479 | nw. | 42 | nw. | 27 | 6 | 13 | 12 | 6.1 | 0.0 | 0.0 |
| *Lower Lake Region.* | | | | | | | 68.0 | −1.7 | | | | | | | | | | 68 | 2.13 | −0.8 | | | | | | | | | | 4.8 | | |
| Buffalo | 767 | 247 | 280 | 29.16 | 29.98 | −.01 | 67.2 | −1.4 | 91 | 6 | 75 | 44 | 22 | 59 | 26 | 60 | 55 | 69 | 1.26 | −1.7 | 8 | 9,759 | sw. | 72 | w. | 21 | 8 | 17 | 6 | 5.1 | 0.0 | 0.0 |
| Canton | 448 | 10 | 61 | 29.46 | 29.92 | ..... | 64.5 | −3.3 | 89 | 4 | 77 | 39 | 16 | 52 | 36 | ..... | ..... | ..... | 2.36 | −0.3 | 9 | 6,140 | w. | 39 | sw. | 28 | 17 | 9 | 5 | 3.7 | 0.0 | 0.0 |
| Oswego | 335 | 76 | 91 | ..... | 29.95 | −.04 | 65.0 | −3.4 | 96 | 2 | 73 | 44 | 24 | 57 | 28 | ..... | ..... | ..... | 1.84 | −0.8 | 10 | 6,010 | s. | 30 | sw. | 21 | 12 | 17 | 2 | ..... | 0.0 | 0.0 |
| Rochester | 523 | 86 | 102 | 29.42 | 29.98 | −.01 | 67.0 | −2.2 | 92 | 6 | 77 | 44 | 23 | 57 | 31 | 59 | 53 | 64 | 1.33 | −1.6 | 7 | 5,071 | sw. | 45 | w. | 21 | 14 | 11 | 6 | 4.7 | 0.0 | 0.0 |
| Syracuse | 597 | 97 | 113 | 29.25 | 29.99 | .00 | 66.4 | −2.2 | 88 | 2 | 76 | 45 | 24 | 56 | 29 | ..... | ..... | ..... | 1.16 | −2.2 | 8 | 6,591 | s. | 37 | w. | 21 | 10 | 16 | 5 | 5.0 | 0.0 | 0.0 |
| Erie | 714 | 130 | 166 | 29.22 | 29.98 | −.03 | 69.0 | −0.6 | 88 | 6 | 77 | 47 | 26 | 61 | 32 | 61 | 56 | 65 | 1.43 | −1.8 | 6 | 8,372 | nw. | 52 | sw. | 21 | 5 | 21 | 5 | 5.0 | 0.0 | 0.0 |
| Cleveland | 762 | 190 | 201 | 29.18 | 29.99 | −.02 | 69.0 | −1.0 | 86 | 2 | 76 | 49 | 23 | 62 | 28 | 62 | 58 | 71 | 3.97 | +0.8 | 9 | 7,727 | s. | 36 | w. | 12 | 5 | 21 | 5 | 5.3 | 0.0 | 0.0 |
| Sandusky | 629 | 62 | 70 | 29.32 | 30.00 | −.01 | 70.3 | −1.5 | 87 | 7 | 78 | 48 | 25 | 62 | 28 | ..... | ..... | ..... | 3.59 | +0.2 | 8 | 4,949 | ne. | 30 | w. | 29 | 5 | 20 | 6 | 5.1 | 0.0 | 0.0 |
| Toledo | 628 | 208 | 243 | 29.32 | 30.00 | .00 | 69.9 | −1.4 | 92 | 7 | 79 | 45 | 22 | 61 | 29 | 62 | 57 | 67 | 2.67 | 0.0 | 10 | 8,380 | sw. | 47 | sw. | 21 | 13 | 13 | 5 | 4.0 | 0.0 | 0.0 |
| Fort Wayne | 856 | 113 | 124 | 29.09 | 30.00 | ..... | 70.0 | −1.1 | 89 | 7 | 79 | 46 | 22 | 60 | 29 | 63 | 59 | 70 | 4.35 | ..... | 12 | 4,848 | sw. | 29 | sw. | 21 | 9 | 12 | 10 | 5.4 | 0.0 | 0.0 |
| Detroit | 730 | 218 | 258 | 29.21 | 29.99 | −.02 | 69.2 | −1.1 | 90 | 4 | 79 | 45 | 22 | 60 | 28 | 61 | 57 | 70 | 1.70 | −1.1 | 10 | 6,820 | sw. | 42 | w. | 21 | 10 | 16 | 5 | 4.9 | 0.0 | 0.0 |
| *Upper Lake Region.* | | | | | | | 64.1 | −2.2 | | | | | | | | | | 74 | 26.8 | −0.3 | | | | | | | | | | 5.4 | | |
| Alpena | 609 | 13 | 92 | 29.32 | 29.99 | −.01 | 61.0 | −3.1 | 84 | 31 | 70 | 39 | 22 | 51 | 29 | 57 | 53 | 75 | 3.07 | −0.3 | 10 | 7,591 | nw. | 44 | nw. | 21 | 9 | 13 | 9 | 5.3 | 0.0 | 0.0 |
| Escanaba | 612 | 54 | 60 | 29.32 | 29.98 | −.01 | 60.6 | −3.9 | 80 | 14 | 69 | 41 | 22 | 52 | 27 | 57 | 54 | 81 | 2.14 | −1.5 | 11 | 6,121 | s. | 28 | ne. | 7 | 12 | 13 | 6 | 4.5 | 0.0 | 0.0 |
| Grand Haven | 632 | 54 | 89 | 29.30 | 29.97 | −.02 | 65.2 | −1.9 | 85 | 1 | 73 | 46 | 22 | 57 | 26 | 60 | 56 | 75 | 3.38 | +0.8 | 11 | 6,138 | nw. | 38 | w. | 12 | 12 | 15 | 4 | 4.8 | 0.0 | 0.0 |
| Grand Rapids | 707 | 70 | 87 | 29.23 | 29.99 | −.01 | 68.2 | −1.8 | 91 | 4 | 79 | 44 | 22 | 58 | 33 | 60 | 56 | 67 | 2.07 | −0.5 | 10 | 3,450 | w. | 22 | w. | 24 | 4 | 17 | 10 | 5.9 | 0.0 | 0.0 |
| Houghton | 668 | 62 | 99 | 29.25 | 29.97 | .00 | 60.7 | −2.6 | 82 | 11 | 70 | 46 | 15 | 52 | 31 | ..... | ..... | ..... | 1.24 | −1.6 | 11 | 6,698 | w. | 43 | w. | 14 | 9 | 13 | 9 | 5.6 | 0.0 | 0.0 |
| Lansing | 878 | 11 | 62 | 29.05 | 29.98 | ..... | 66.7 | −1.9 | 91 | 4 | 79 | 40 | 22 | 58 | 36 | 60 | 57 | 78 | 1.27 | −1.4 | 11 | 2,995 | sw. | 18 | sw. | 21 | 6 | 16 | 9 | 5.5 | 0.0 | 0.0 |
| Ludington | 637 | 60 | 66 | 29.30 | 29.99 | ..... | 62.6 | ..... | 81 | 3 | 70 | 46 | 26 | 55 | 24 | 58 | 54 | 75 | 2.88 | ..... | 10 | 5,942 | s. | 28 | s. | 14 | 13 | 14 | 4 | 4.3 | 0.0 | 0.0 |
| Marquette | 734 | 77 | 111 | 29.20 | 30.00 | +.02 | 60.8 | −2.7 | 85 | 6 | 69 | 44 | 22 | 52 | 32 | 55 | 51 | 73 | 1.08 | −1.8 | 11 | 6,370 | nw. | 25 | sw. | 13 | 4 | 11 | 16 | 7.0 | 0.0 | 0.0 |
| Port Huron | 638 | 70 | 120 | 29.29 | 29.98 | −.02 | 66.9 | −0.9 | 88 | 10 | 77 | 42 | 23 | 57 | 31 | 59 | 54 | 69 | 0.99 | −1.6 | 11 | 7,238 | ne. | 39 | w. | 24 | 6 | 22 | 3 | 4.9 | 0.0 | 0.0 |
| Saginaw | 641 | 69 | 77 | 29.30 | 29.98 | ..... | 66.4 | ..... | 89 | 7 | 77 | 39 | 22 | 55 | 30 | 61 | 58 | 76 | 2.98 | +0.1 | 9 | 4,896 | sw. | 28 | sw. | 21 | 8 | 16 | 7 | 5.6 | 0.0 | 0.0 |
| Sault Sainte Marie | 614 | 11 | 52 | 29.29 | 29.98 | −.01 | 58.4 | −2.2 | 80 | 3 | 67 | 42 | 23 | 49 | 30 | 54 | 51 | 80 | 3.20 | +0.1 | 11 | 5,005 | nw. | 40 | nw. | 21 | 7 | 12 | 12 | 6.1 | 0.0 | 0.0 |
| Chicago | 823 | 140 | 310 | 29.12 | 29.99 | −.01 | 70.8 | −2.0 | 89 | 14 | 77 | 54 | 22 | 65 | 23 | 64 | 60 | 71 | 7.76 | +4.9 | 11 | 7,002 | ne. | 45 | nw. | 11 | 9 | 13 | 9 | 5.2 | 0.0 | 0.0 |
| Green Bay | 617 | 109 | 144 | 29.32 | 29.97 | −.02 | 65.3 | −1.7 | 87 | 6 | 75 | 44 | 22 | 56 | 28 | 58 | 54 | 72 | 3.65 | +0.6 | 9 | 6,730 | s. | 35 | nw. | 21 | 4 | 12 | 15 | 7.0 | 0.0 | 0.0 |
| Milwaukee | 681 | 125 | 139 | 29.26 | 29.99 | −.01 | 67.8 | −1.4 | 89 | 14 | 75 | 48 | 22 | 61 | 25 | 61 | 57 | 70 | 2.91 | +0.1 | 12 | 6,130 | ne. | 27 | sw. | 21 | 9 | 13 | 9 | 5.4 | 0.0 | 0.0 |
| Duluth | 1,133 | 11 | 47 | 28.78 | 29.99 | +.02 | 60.3 | −2.3 | 84 | 30 | 70 | 38 | 24 | 50 | 32 | 56 | 52 | 77 | 1.76 | −1.8 | 12 | 7,340 | nw. | 37 | nw. | 24 | 12 | 16 | 3 | 4.6 | 0.0 | 0.0 |
| *North Dakota.* | | | | | | | 63.9 | −2.3 | | | | | | | | | | 68 | 1.69 | −0.6 | | | | | | | | | | 5.3 | | |
| Moorhead | 940 | 50 | 58 | 28.99 | 30.00 | +.04 | 63.9 | −2.2 | 87 | 13 | 75 | 40 | 24 | 53 | 30 | 57 | 52 | 71 | 2.83 | −0.3 | 8 | 4,549 | n. | 25 | nw. | 25 | 7 | 11 | 13 | 6.1 | 0.0 | 0.0 |
| Bismarck | 1,674 | 8 | 57 | 28.28 | 30.05 | +.11 | 65.4 | −1.9 | 89 | 30 | 77 | 43 | 22 | 54 | 37 | 56 | 52 | 69 | 0.63 | −1.4 | 4 | 5,094 | nw. | 36 | nw. | 13 | 8 | 13 | 10 | 5.7 | 0.0 | 0.0 |
| Devils Lake | 1,478 | 11 | 44 | 28.44 | 30.00 | +.06 | 62.0 | −3.1 | 90 | 30 | 75 | 36 | 24 | 49 | 34 | 55 | 50 | 71 | 2.25 | −0.5 | 16 | 5,711 | w. | 32 | nw. | 17 | 13 | 11 | 7 | 4.5 | 0.0 | 0.0 |
| Ellendale | 1,457 | 10 | 56 | 28.47 | 30.02 | ..... | 63.8 | ..... | 87 | 13 | 76 | 39 | 24 | 52 | 32 | ..... | ..... | ..... | 1.45 | ..... | 9 | 6,838 | nw. | 40 | n. | 26 | 9 | 17 | 5 | 5.2 | 0.0 | 0.0 |
| Grand Forks | 835 | 12 | 89 | ..... | ..... | ..... | 62.9 | ..... | 90 | 30 | 76 | 34 | 24 | 50 | 39 | ..... | ..... | ..... | 3.21 | ..... | 11 | ..... | se. | 60 | ne. | 17 | 11 | 8 | 12 | ..... | 0.0 | 0.0 |
| Williston | 1,878 | 41 | 48 | 28.04 | 29.99 | +.06 | 64.2 | −1.9 | 91 | 30 | 77 | 40 | 1 | 52 | 37 | 55 | 49 | 63 | 1.05 | −0.3 | 7 | 4,218 | n. | 31 | e. | 10 | 12 | 12 | 7 | 4.9 | 0.0 | 0.0 |
| *Upper Mississippi Valley.* | | | | | | | 72.3 | −0.8 | | | | | | | | | | 74 | 4.03 | +0.8 | | | | | | | | | | 5.2 | | |
| Minneapolis | 918 | 102 | 208 | 29.00 | 29.97 | ..... | 67.2 | ..... | 88 | 13 | 77 | 46 | 22 | 58 | 30 | ..... | ..... | ..... | 1.98 | −1.7 | 13 | 6,604 | nw. | 32 | n. | 19 | 5 | 17 | 9 | 5.9 | 0.0 | 0.0 |
| St. Paul | 837 | 236 | 261 | 29.10 | 30.00 | +.03 | 66.9 | −2.5 | 88 | 11 | 77 | 45 | 22 | 57 | 31 | ..... | ..... | ..... | 1.92 | −1.5 | 10 | 6,772 | nw. | 37 | sw. | 13 | 7 | 19 | 5 | 5.0 | 0.0 | 0.0 |
| La Crosse | 714 | 11 | 48 | 29.23 | 29.98 | .00 | 68.0 | −2.0 | 91 | 11 | 79 | 43 | 22 | 58 | 34 | ..... | ..... | ..... | 2.30 | −1.1 | 16 | 2,572 | se. | 16 | s. | 13 | 11 | 9 | 11 | 5.3 | 0.0 | 0.0 |
| Madison | 974 | 70 | 78 | 28.97 | 29.99 | .00 | 67.9 | −1.9 | 89 | 11 | 76 | 48 | 22 | 59 | 31 | 61 | 58 | 75 | 5.59 | +2.4 | 15 | 4,701 | nw. | 25 | ne. | 4 | 10 | 10 | 11 | 5.3 | 0.0 | 0.0 |
| Wausau | 1,247 | 4 | ..... | 28.69 | 30.02 | ..... | 62.4 | ..... | 84 | 11 | 73 | 38 | 25 | 52 | 32 | ..... | ..... | ..... | 1.96 | ..... | 8 | ..... | nw. | ..... | ..... | ..... | 14 | 6 | 11 | 4.9 | 0.0 | 0.0 |
| Charles City | 1,015 | 10 | 49 | 28.94 | 29.99 | +.02 | 68.1 | −2.6 | 91 | 11 | 79 | 43 | 22 | 57 | 31 | 62 | 58 | 75 | 5.10 | +1.7 | 14 | 3,173 | se. | 22 | nw. | 3 | 11 | 14 | 6 | 4.8 | 0.0 | 0.0 |
| Davenport | 606 | 71 | 79 | 29.33 | 29.98 | .00 | 72.9 | −0.2 | 97 | 11 | 83 | 47 | 22 | 62 | 29 | 64 | 60 | 70 | 1.61 | −2.0 | 10 | 4,273 | e. | 29 | nw. | 4 | 10 | 9 | 12 | 5.6 | 0.0 | 0.0 |
| Des Moines | 861 | 84 | 97 | 29.08 | 29.97 | .00 | 71.4 | −1.7 | 95 | 11 | 81 | 48 | 22 | 62 | 31 | 65 | 63 | 78 | 5.34 | +1.7 | 14 | 3,927 | n. | 34 | e. | 4 | 12 | 5 | 14 | 5.6 | 0.0 | 0.0 |
| Dubuque | 698 | 81 | 96 | 29.26 | 30.00 | +.02 | 69.6 | −2.1 | 94 | 11 | 79 | 45 | 25 | 60 | 28 | 62 | 58 | 72 | 4.77 | +1.7 | 12 | 3,322 | nw. | 29 | sw. | 11 | 9 | 10 | 12 | 6.1 | 0.0 | 0.0 |
| Keokuk | 614 | 64 | 78 | 29.32 | 29.98 | .00 | 74.9 | −0.1 | 98 | 7 | 84 | 51 | 23 | 65 | 25 | 66 | 62 | 69 | 3.63 | +0.4 | 15 | 3,973 | ne. | 21 | sw. | 27 | 11 | 8 | 12 | 5.5 | 0.0 | 0.0 |
| Cairo | 358 | 87 | 93 | 29.60 | 29.97 | −.02 | 78.4 | +0.6 | 96 | 12 | 87 | 57 | 23 | 70 | 22 | 72 | 69 | 79 | 2.48 | −0.4 | 10 | 4,471 | s. | 36 | w. | 3 | 10 | 11 | 10 | 5.5 | 0.0 | 0.0 |
| Peoria | 609 | 11 | 45 | 29.34 | 30.00 | +.01 | 73.4 | +0.9 | 97 | 11 | 85 | 46 | 22 | 62 | 31 | 66 | 63 | 77 | 2.84 | −0.1 | 11 | 2,721 | ne. | 29 | sw. | 7 | 18 | 5 | 8 | 3.9 | 0.0 | 0.0 |
| Springfield, Ill | 636 | 10 | 91 | 29.30 | 29.96 | −.03 | 75.0 | +0.5 | 97 | 11 | 85 | 51 | 23 | 65 | 28 | 68 | 65 | 77 | 5.35 | +2.6 | 9 | 4,474 | ne. | 38 | nw. | 4 | 13 | 9 | 9 | 4.6 | 0.0 | 0.0 |
| Hannibal | 534 | 74 | 109 | 29.40 | 29.96 | −.02 | 75.6 | +0.6 | 98 | 11 | 86 | 50 | 23 | 66 | 29 | ..... | ..... | ..... | 7.29 | +3.9 | 12 | 4,675 | sw. | 28 | nw. | 4 | 14 | 8 | 9 | 4.6 | 0.0 | 0.0 |
| St. Louis | 568 | 265 | 303 | 29.37 | 29.96 | −.03 | 77.9 | +0.6 | 98 | 11 | 86 | 56 | 22 | 69 | 26 | 69 | 66 | 72 | 6.19 | +3.5 | 12 | 6,575 | s. | 44 | w. | 5 | 10 | 10 | 11 | 5.4 | 0.0 | 0.0 |
| *Missouri Valley.* | | | | | | | 73.6 | −0.1 | | | | | | | | | | 71 | 4.08 | +0.7 | | | | | | | | | | 4.9 | | |
| Columbia, Mo | 784 | 11 | 84 | 29.14 | 29.96 | −.01 | 76.2 | +1.5 | 97 | 11 | 86 | 48 | 23 | 66 | 31 | ..... | ..... | ..... | 3.92 | +0.9 | 9 | 4,094 | se. | 40 | sw. | 5 | 10 | 13 | 8 | 5.3 | 0.0 | 0.0 |
| Kansas City | 963 | 161 | 181 | 28.94 | 29.95 | −.02 | 77.3 | +1.5 | 99 | 7 | 86 | 52 | 22 | 68 | 25 | 68 | 63 | 67 | 2.88 | −1.9 | 13 | 6,352 | n. | 31 | n. | 21 | 14 | 10 | 7 | 4.5 | 0.0 | 0.0 |
| St. Joseph | 967 | 11 | 49 | 28.93 | 29.94 | ..... | 76.2 | ..... | 98 | 11 | 86 | 50 | 22 | 66 | 31 | 67 | 64 | 72 | 4.34 | ..... | 17 | 4,428 | se. | 30 | nw. | 4 | 13 | 15 | 3 | 4.2 | 0.0 | 0.0 |
| Springfield, Mo | 1,324 | 98 | 104 | 28.60 | 29.97 | .00 | 78.6 | +3.8 | 100 | 14 | 89 | 54 | 23 | 68 | 33 | 68 | 64 | 68 | 0.78 | −3.5 | 6 | 5,902 | s. | 30 | n. | 21 | 20 | 9 | 2 | 2.8 | 0.0 | 0.0 |
| Iola | 984 | 11 | 50 | 28.92 | 29.94 | −.02 | 80.8 | +4.5 | 104 | 3 | 94 | 51 | 23 | 68 | 38 | ..... | ..... | ..... | 3.39 | −0.1 | 10 | 4,039 | s. | 21 | n. | 21 | 12 | 16 | 3 | 4.4 | 0.0 | 0.0 |
| Topeka | 987 | 92 | 107 | ..... | ..... | ..... | 76.9 | +0.9 | 100 | 11 | 88 | 51 | 22 | 66 | 30 | ..... | ..... | ..... | 4.78 | +0.5 | 12 | 6,288 | se. | 50 | nw. | 7 | 13 | 7 | 11 | 4.6 | 0.0 | 0.0 |
| Drexel | 1,299 | 10 | 54 | 28.60 | 29.97 | ..... | 70.8 | ..... | 95 | 11 | 81 | 43 | 22 | 60 | 28 | ..... | ..... | ..... | 5.34 | ..... | 15 | 5,461 | ne. | 30 | nw. | 4 | 12 | 9 | 10 | 5.0 | 0.0 | 0.0 |
| Lincoln | 1,189 | 11 | 84 | 28.72 | 29.96 | +.01 | 73.2 | −1.1 | 96 | 11 | 83 | 46 | 22 | 63 | 32 | 66 | 62 | 73 | 5.50 | +1.8 | 13 | 5,934 | ne. | 67 | nw. | 4 | 6 | 12 | 13 | 6.4 | 0.0 | 0.0 |
| Omaha | 1,105 | 115 | 122 | 28.82 | 29.97 | +.01 | 72.9 | −1.5 | 96 | 11 | 82 | 48 | 22 | 64 | 25 | 66 | 63 | 74 | 4.24 | +0.6 | 15 | 4,685 | ne. | 38 | n. | 11 | 13 | 10 | 8 | 4.7 | 0.0 | 0.0 |
| Valentine | 2,598 | 47 | 54 | 27.33 | 30.01 | +.07 | 67.8 | −3.9 | 94 | 13 | 80 | 39 | 22 | 56 | 35 | 60 | 56 | 71 | 2.61 | −0.2 | 14 | 5,312 | s. | 30 | ne. | 3 | 6 | 17 | 8 | 5.5 | 0.0 | 0.0 |
| Sioux City | 1,135 | 94 | 164 | 28.80 | 29.99 | +.04 | 70.4 | −1.6 | 89 | 19 | 80 | 43 | 22 | 61 | 27 | 63 | 60 | 74 | 7.63 | +4.6 | 15 | 6,028 | se. | 36 | w. | 15 | 11 | 13 | 7 | 5.0 | 0.0 | 0.0 |
| Huron | 1,306 | 59 | 74 | 28.64 | 30.02 | +.07 | 68.5 | −0.9 | 93 | 13 | 79 | 39 | 22 | 58 | 32 | 60 | 56 | 68 | 2.89 | +0.2 | 12 | 4,987 | se. | 32 | ne. | 20 | 9 | 16 | 6 | 5.2 | 0.0 | 0.0 |
| Pierre | 1,572 | 70 | 75 | 28.35 | 29.99 | +.05 | 69.8 | −3.0 | 93 | 18 | 80 | 44 | 22 | 59 | 34 | 62 | 57 | 68 | 3.76 | +1.8 | 10 | 4,719 | e. | 48 | nw. | 5 | 11 | 9 | 11 | 5.4 | 0.0 | 0.0 |
| Yankton | 1,233 | 49 | 57 | 28.69 | 29.98 | +.03 | 70.2 | −1.8 | 90 | 14 | 80 | 43 | 22 | 60 | 27 | ..... | ..... | ..... | 6.55 | +3.4 | 12 | 3,938 | se. | 47 | nw. | 3 | 10 | 14 | 7 | 5.4 | 0.0 | 0.0 |

TABLE I.—*Climatological data for Weather Bureau stations, August, 1923*—Continued.

| Districts and stations. | Elevation of instruments. | | | Pressure. | | | Temperature of the air. | | | | | | | | | | Mean wet thermometer. | Mean temperature of the dew point. | Mean relative humidity. | Precipitation. | | | Wind. | | | | Clear days. | Partly cloudy days. | Cloudy days. | Average cloudiness, tenths. | Total snowfall. | Snow, sleet and ice on ground at end of month. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer above sea level. | Thermometer above ground. | Anemometer above ground. | Station, reduced to mean of 24 hours. | Sea level, reduced to mean of 24 hours. | Departure from normal. | Mean max. + mean min. ÷2. | Departure from normal. | Maximum. | Date. | Mean maximum. | Minimum. | Date. | Mean minimum. | Greatest daily range. | | | | Total. | Departure from normal. | Days with 0.01, or more. | Total movement. | Prevailing direction. | Maximum velocity. Miles per hour. | Maximum velocity. Direction. | Maximum velocity. Date. | | | | | | |
| | *Ft.* | *Ft.* | *Ft.* | *In.* | *In.* | *In.* | °*F.* | °*F.* | °*F.* | | °*F.* | °*F.* | | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | % | *In.* | *In.* | | *Miles.* | | | | | | | *0–10* | *In.* | *In.* |
| *Northern Slope.* | | | | | | | **65.4** | **−0.9** | | | | | | | | | | | **64** | **1.76** | **+0.5** | | | | | | | | **4.5** | | |
| Billings | 3,140 | 5 | .... | 27.42 | 29.99 | +.08 | 68.2 | ..... | 104 | 12 | 86 | 44 | 1 | 50 | 55 | .... | .... | .... | .... | 2.08 | ..... | 13 | .... | ne. | .... | ..... | .... | 9 | 12 | 10 | .... | 0.0 | 0.0 |
| Havre | 2,505 | 11 | 44 | 27.42 | 29.99 | +.08 | 65.0 | −0.4 | 94 | 12 | 79 | 40 | 6 | 51 | 44 | 56 | 50 | 67 | 1.47 | +0.2 | 7 | 3,146 | e. | 36 | w. | 9 | 16 | 14 | 1 | 3.7 | 0.0 | 0.0 |
| Helena | 4,110 | 87 | 112 | 25.87 | 29.99 | +.05 | 64.8 | −0.2 | 93 | 12 | 77 | 41 | 4 | 52 | 38 | 53 | 44 | 56 | 1.66 | +1.0 | 9 | 5,017 | sw. | 32 | nw. | 25 | 10 | 15 | 6 | 4.8 | 0.0 | 0.0 |
| Kalispell | 2,973 | 48 | 56 | 26.95 | 29.96 | +.03 | 64.0 | +1.1 | 92 | 18 | 77 | 44 | 7 | 51 | 36 | 53 | 45 | 59 | 0.96 | +0.1 | 9 | 3,919 | nw. | 29 | sw. | 9 | 18 | 9 | 4 | 3.7 | 0.0 | 0.0 |
| Miles City | 2,371 | 48 | 55 | 27.51 | 30.02 | +.09 | 69.2 | −2.3 | 99 | 12 | 81 | 47 | 1 | 57 | 40 | 57 | 50 | 59 | 0.57 | −0.5 | 10 | 3,459 | ne. | 22 | se. | 27 | 13 | 13 | 5 | 3.8 | 0.0 | 0.0 |
| Rapid City | 3,259 | 50 | 58 | 26.67 | 30.03 | +.10 | 67.0 | −1.8 | 90 | 13 | 77 | 50 | 2 | 57 | 30 | 58 | 52 | 63 | 3.50 | +1.4 | 14 | 4,592 | w. | 36 | nw. | 5 | 8 | 13 | 10 | 5.6 | 0.0 | 0.0 |
| Cheyenne | 6,088 | 84 | 101 | 24.13 | 29.98 | +.06 | 63.7 | −1.9 | 84 | 13 | 75 | 42 | 27 | 53 | 33 | 54 | 50 | 69 | 2.06 | +0.6 | 16 | 6,812 | s. | 35 | w. | 5 | 7 | 17 | 7 | 5.4 | 0.0 | 0.0 |
| Lander | 5,372 | 60 | 68 | 24.74 | 29.99 | +.07 | 66.2 | +0.5 | 90 | 13 | 81 | 43 | 27 | 52 | 37 | 54 | 48 | 59 | 0.23 | −0.3 | 5 | 3,630 | sw. | 36 | sw. | 13 | 12 | 17 | 2 | 4.5 | 0.0 | 0.0 |
| Sheridan | 3,790 | 10 | 47 | 26.18 | 30.03 | ..... | 64.4 | ..... | 94 | 12 | 78 | 43 | 27 | 51 | 43 | 56 | 51 | 72 | 1.44 | ..... | 12 | 2,332 | nw. | 25 | sw. | 8 | 13 | 12 | 6 | 4.6 | 0.0 | 0.0 |
| Yellowstone Park | 6,200 | 11 | 48 | 24.00 | 30.02 | +.09 | 58.2 | −2.7 | 88 | 13 | 74 | 37 | 4 | 43 | 45 | 48 | 42 | 64 | 0.70 | −0.3 | 11 | 4,403 | s. | 34 | s. | 9 | 9 | 17 | 5 | 5.0 | 0.0 | 0.0 |
| North Platte | 2,821 | 11 | 51 | 27.14 | 30.02 | +.08 | 70.2 | −0.6 | 91 | 20 | 82 | 47 | 22 | 59 | 36 | 62 | 59 | 77 | 4.70 | +2.2 | 12 | 3,844 | e. | 37 | nw. | 4 | 17 | 6 | 8 | 3.9 | 0.0 | 0.0 |
| *Middle Slope.* | | | | | | | **76.4** | **+0.9** | | | | | | | | | | | **61** | **2.79** | **+0.4** | | | | | | | | **4.2** | | |
| Denver | 5,292 | 106 | 113 | 24.84 | 30.01 | +.09 | 68.4 | −2.3 | 87 | 13 | 79 | 53 | 29 | 58 | 30 | 57 | 52 | 65 | 3.87 | +2.5 | 16 | 4,225 | s. | 30 | n. | 26 | 6 | 19 | 6 | 5.5 | 0.0 | 0.0 |
| Pueblo | 4,685 | 80 | 86 | 25.36 | 29.97 | +.06 | 70.8 | −1.3 | 93 | 3 | 82 | 53 | 23 | 59 | 33 | 60 | 55 | 68 | 4.65 | +3.1 | 15 | 4,061 | nw. | 38 | s. | 15 | 5 | 19 | 7 | 5.6 | 0.0 | 0.0 |
| Concordia | 1,392 | 50 | 58 | 28.49 | 29.93 | −.02 | 76.2 | −0.3 | 97 | 11 | 87 | 51 | 22 | 65 | 36 | 66 | 62 | 67 | 2.75 | −0.1 | 14 | 4,856 | ne. | 30 | nw. | 14 | 10 | 18 | 3 | 5.0 | 0.0 | 0.0 |
| Dodge City | 2,509 | 11 | 51 | 27.42 | 29.95 | +.02 | 77.9 | +0.2 | 100 | 15 | 91 | 50 | 23 | 65 | 36 | 64 | 58 | 58 | 1.46 | −1.1 | 13 | 6,009 | s. | 29 | s. | 30 | 18 | 10 | 3 | 3.4 | 0.0 | 0.0 |
| Wichita | 1,358 | 139 | 158 | 28.52 | 29.90 | −.05 | 81.4 | +3.9 | 104 | 14 | 93 | 56 | 22 | 70 | 31 | 66 | 59 | 54 | 0.42 | −2.7 | 5 | 9,081 | s. | 42 | se. | 25 | 20 | 9 | 2 | 3.2 | 0.0 | 0.0 |
| Broken Arrow | 765 | 11 | 52 | 29.16 | 29.97 | ..... | 83.0 | ..... | 107 | 1 | 95 | 58 | 23 | 71 | 34 | .... | .... | .... | 2.28 | ..... | 5 | 7,654 | s. | 33 | n. | 21 | 16 | 10 | 5 | 3.8 | 0.0 | 0.0 |
| Muskogee | 652 | 4 | .... | .... | .... | .... | 85.1 | ..... | 110 | 1 | 99 | 59 | 23 | 71 | 41 | .... | .... | .... | 2.23 | ..... | 7 | .... | s. | .... | .... | .... | 16 | 14 | 1 | .... | 0.0 | 0.0 |
| Oklahoma City | 1,214 | 10 | 47 | 28.69 | 29.93 | −.01 | 83.6 | +5.1 | 106 | 1 | 96 | 61 | 23 | 72 | 31 | 67 | 60 | 53 | 3.57 | +0.4 | 3 | 6,342 | s. | 31 | s. | 31 | 23 | 6 | 2 | 2.8 | 0.0 | 0.0 |
| *Southern Slope.* | | | | | | | **80.6** | **+1.5** | | | | | | | | | | | **54** | **1.02** | **−1.3** | | | | | | | | **37** | | |
| Abilene | 1,738 | 10 | 52 | 28.17 | 29.93 | +.01 | 83.1 | +1.9 | 102 | 4 | 94 | 63 | 24 | 72 | 29 | 67 | 59 | 53 | 1.28 | −0.7 | 2 | 6,056 | s. | 23 | se. | 9 | 18 | 9 | 4 | 3.6 | 0.0 | 0.0 |
| Amarillo | 3,676 | 10 | 49 | 26.33 | 29.97 | +.05 | 77.2 | +2.6 | 99 | 4 | 90 | 55 | 22 | 65 | 31 | 63 | 56 | 56 | 1.54 | −1.3 | 8 | 6,764 | s. | 32 | ne. | 21 | 12 | 17 | 2 | 4.2 | 0.0 | 0.0 |
| Del Rio | 944 | 64 | 71 | 28.96 | 29.92 | +.02 | 85.0 | +1.0 | 98 | 3 | 95 | 72 | 23 | 75 | 23 | .... | .... | .... | 0.49 | −2.1 | 4 | 6,747 | se. | 37 | n. | 27 | 19 | 10 | 2 | 3.2 | 0.0 | 0.0 |
| Roswell | 3,566 | 75 | 85 | 26.38 | 29.90 | +.02 | 77.0 | +0.4 | 99 | 3 | 89 | 58 | 23 | 65 | 34 | 62 | 54 | 53 | 0.78 | −1.2 | 5 | 4,930 | se. | 31 | se. | 6 | 11 | 17 | 3 | 3.9 | 0.0 | 0.0 |
| *Southern Plateau.* | | | | | | | **76.4** | **−1.0** | | | | | | | | | | | **52** | **1.37** | **0.0** | | | | | | | | **3.1** | | |
| El Paso | 3,762 | 110 | 133 | 26.19 | 29.86 | +.02 | 78.8 | +0.2 | 101 | 1 | 89 | 62 | 26 | 68 | 28 | 64 | 56 | 54 | 2.96 | +1.2 | 12 | 7,018 | se. | 37 | s. | 16 | 14 | 13 | 4 | 3.9 | 0.0 | 0.0 |
| Santa Fe | 7,013 | 38 | 53 | 23.39 | 29.94 | +.05 | 65.8 | −1.6 | 87 | 1 | 77 | 47 | 23 | 55 | 30 | 54 | 49 | 65 | 2.33 | 0.0 | 20 | 3,910 | se. | 26 | se. | 5 | 8 | 14 | 9 | 5.4 | 0.0 | 0.0 |
| Flagstaff | 6,907 | 10 | 59 | .... | .... | .... | 61.8 | −1.0 | 82 | 8 | 74 | 42 | 22 | 49 | 34 | .... | .... | 68 | 1.86 | −0.9 | 13 | 4,485 | w. | 22 | w. | 3 | 7 | 17 | 7 | .... | 0.0 | 0.0 |
| Phoenix | 1,108 | 11 | 81 | 28.70 | 29.81 | +.02 | 87.2 | −1.8 | 105 | 2 | 99 | 70 | 22 | 76 | 33 | 71 | 63 | 50 | 0.65 | −0.3 | 8 | 3,806 | e. | 27 | nw. | 31 | 17 | 9 | 5 | 3.5 | 0.0 | 0.0 |
| Yuma | 141 | 9 | 54 | 29.64 | 29.78 | +.02 | 89.2 | −1.2 | 107 | 28 | 103 | 68 | 8 | 75 | 37 | 72 | 64 | 50 | 0.29 | −0.1 | 2 | 3,340 | sw. | 18 | ne. | 24 | 27 | 4 | 0 | 1.2 | 0.0 | 0.0 |
| Independence | 3,957 | 5 | 25 | 25.98 | 29.93 | +.12 | 75.6 | −0.8 | 97 | 26 | 91 | 52 | 10 | 60 | 38 | 54 | 35 | 28 | 0.11 | 0.0 | 2 | 5,598 | nw. | 35 | se. | 11 | 28 | 1 | 2 | 1.6 | 0.0 | 0.0 |
| *Middle Plateau.* | | | | | | | **69.8** | **−1.3** | | | | | | | | | | | **41** | **1.25** | **+0.5** | | | | | | | | **3.2** | | |
| Reno | 4,532 | 74 | 81 | 25.51 | 29.93 | +.09 | 68.1 | +1.1 | 93 | 11 | 85 | 44 | 4 | 51 | 42 | 50 | 37 | 42 | 0.73 | +0.5 | 5 | 4,925 | w. | 30 | w. | 21 | 22 | 4 | 5 | 2.4 | 0.0 | 0.0 |
| Tonopah | 6,090 | 12 | 20 | 24.10 | 29.90 | ..... | 70.0 | ..... | 87 | 1 | 81 | 52 | 29 | 59 | 29 | 49 | 29 | 27 | 0.14 | −0.2 | 4 | 5,406 | w. | 22 | e. | 16 | 23 | 6 | 2 | 2.3 | 0.0 | 0.0 |
| Winnemucca | 4,344 | 18 | 56 | 25.63 | 29.95 | +.07 | 67.8 | −1.2 | 96 | 12 | 86 | 43 | 6 | 49 | 49 | 50 | 36 | 39 | 0.25 | +0.1 | 3 | 4,089 | sw. | 40 | s. | 28 | 23 | 4 | 4 | 2.1 | 0.0 | 0.0 |
| Modena | 5,479 | 10 | 43 | 24.66 | 29.91 | +.05 | 67.2 | −1.4 | 90 | 27 | 83 | 44 | 6 | 51 | 44 | 50 | 37 | 43 | 2.13 | +0.3 | 10 | 7,221 | sw. | 44 | sw. | 4 | 17 | 13 | 1 | 3.0 | 0.0 | 0.0 |
| Salt Lake City | 4,360 | 163 | 203 | 25.64 | 29.92 | +.01 | 73.0 | −1.5 | 90 | 9 | 85 | 52 | 30 | 61 | 31 | 56 | 44 | 41 | 2.41 | +1.6 | 6 | 5,105 | sw. | 60 | w. | 2 | 16 | 11 | 4 | 3.5 | 0.0 | 0.0 |
| Grand Junction | 4,602 | 60 | 68 | 25.43 | 29.96 | +.06 | 72.8 | −3.3 | 92 | 5 | 85 | 55 | 30 | 60 | 33 | 58 | 50 | 53 | 1.86 | +0.8 | 12 | 4,451 | se. | 35 | se. | 29 | 7 | 13 | 11 | 5.7 | 0.0 | 0.0 |
| *Northern Plateau.* | | | | | | | **71.4** | **+1.0** | | | | | | | | | | | **45** | **0.77** | **+0.4** | | | | | | | | **3.3** | | |
| Baker | 3,471 | 48 | 53 | 26.47 | 30.00 | +.05 | 65.6 | +0.7 | 95 | 17 | 81 | 39 | 5 | 50 | 41 | 53 | 45 | 53 | 0.77 | +0.4 | 7 | 3,927 | se. | 18 | se. | 21 | 12 | 16 | 3 | 4.0 | 0.0 | 0.0 |
| Boise | 2,739 | 78 | 86 | 27.13 | 29.93 | .00 | 73.1 | +1.3 | 99 | 17 | 88 | 50 | 1 | 58 | 38 | 56 | 44 | 41 | 0.20 | 0.0 | 3 | 3,296 | se. | 24 | nw. | 7 | 21 | 7 | 3 | 2.5 | 0.0 | 0.0 |
| Lewiston | 757 | 40 | 48 | 29.15 | 29.95 | .00 | 75.2 | +1.7 | 106 | 18 | 92 | 53 | 4 | 59 | 45 | .... | .... | .... | 0.38 | 0.0 | 2 | 2,160 | e. | 29 | se. | 18 | 19 | 8 | 4 | 3.0 | 0.0 | 0.0 |
| Pocatello | 4,477 | 60 | 68 | 25.50 | 29.92 | .00 | 69.6 | −0.9 | 94 | 12 | 85 | 47 | 7 | 55 | 39 | 53 | 40 | 43 | 0.60 | 0.0 | 6 | 5,046 | se. | 40 | sw. | 19 | 15 | 12 | 4 | 4.0 | 0.0 | 0.0 |
| Spokane | 1,929 | 101 | 110 | 27.95 | 29.96 | +.01 | 69.8 | +1.7 | 99 | 17 | 84 | 47 | 3 | 56 | 37 | 56 | 46 | 51 | 2.12 | +1.6 | 6 | 3,171 | sw. | 23 | se. | 18 | 15 | 12 | 4 | 3.8 | 0.0 | 0.0 |
| Walla Walla | 991 | 57 | 65 | 28.89 | 29.94 | +.02 | 75.4 | +1.6 | 103 | 16 | 88 | 56 | 3 | 62 | 39 | 58 | 46 | 39 | 0.57 | +0.1 | 4 | 3,167 | s. | 15 | sw. | 19 | 21 | 9 | 1 | 2.4 | 0.0 | 0.0 |
| *North Pacific Coast Region.* | | | | | | | **65.1** | **+2.8** | | | | | | | | | | | **76** | **1.18** | **+0.4** | | | | | | | | **4.0** | | |
| North Head | 211 | 11 | 56 | 29.84 | 30.06 | +.03 | 61.4 | +3.5 | 71 | 20 | 65 | 52 | 2 | 58 | 15 | 59 | 58 | 89 | 0.24 | −0.3 | 4 | 8,495 | n. | 34 | n. | 2 | 8 | 14 | 9 | 5.6 | 0.0 | 0.0 |
| Port Angeles | 29 | 8 | 53 | 30.04 | 30.07 | ..... | 60.4 | ..... | 78 | 29 | 69 | 42 | 2 | 52 | 28 | .... | .... | .... | 1.38 | +0.7 | 4 | 4,834 | sw. | 22 | w. | 9 | 12 | 14 | 5 | 4.5 | 0.0 | 0.0 |
| Seattle | 125 | 215 | 250 | 29.92 | 30.06 | +.06 | 65.7 | +2.6 | 86 | 16 | 75 | 50 | 3 | 56 | 27 | 58 | 54 | 69 | 1.98 | +1.5 | 5 | 4,188 | n. | 22 | w. | 22 | 11 | 17 | 3 | 4.1 | 0.0 | 0.0 |
| Tacoma | 213 | 113 | 120 | 29.81 | 30.03 | +.01 | 66.0 | +3.0 | 88 | 16 | 76 | 52 | 2 | 56 | 29 | .... | .... | .... | 2.28 | +1.6 | 4 | 4,667 | n. | 27 | w. | 22 | 7 | 21 | 3 | 5.2 | 0.0 | 0.0 |
| Tatoosh Island | 86 | 9 | 57 | 29.97 | 30.06 | +.06 | 57.1 | +1.8 | 68 | 23 | 62 | 49 | 28 | 53 | 19 | 56 | 55 | 96 | 1.80 | −0.3 | 10 | 6,648 | s. | 42 | e. | 21 | 1 | 15 | 15 | 0.5 | 0.0 | 0.0 |
| Yakima | 1,071 | 5 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 0.0 | 0.0 |
| Medford | 1,425 | 4 | .... | .... | .... | .... | 70.6 | ..... | 102 | 16 | 91 | 46 | 5 | 50 | 48 | .... | .... | .... | 0.89 | ..... | 3 | .... | nw. | .... | .... | .... | 16 | 8 | 7 | .... | 0.0 | 0.0 |
| Portland, Oreg. | 153 | 68 | 106 | 29.86 | 30.02 | +.01 | 70.6 | +3.9 | 95 | 28 | 82 | 53 | 2 | 60 | 31 | 61 | 55 | 63 | 0.26 | −0.4 | 2 | 3,475 | nw. | 17 | nw. | 27 | 14 | 11 | 6 | 4.5 | 0.0 | 0.0 |
| Roseburg | 510 | 9 | 57 | 29.46 | 30.01 | +.01 | 70.0 | +2.0 | 97 | 15 | 85 | 48 | 8 | 54 | 41 | 59 | 53 | 63 | 0.30 | 0.0 | 2 | 2,086 | nw. | 14 | w. | 20 | 17 | 8 | 6 | 3.8 | 0.0 | 0.0 |
| *Middle Pacific Coast Region.* | | | | | | | **66.0** | **+1.2** | | | | | | | | | | | **67** | **0.01** | **0.0** | | | | | | | | **3.8** | | |
| Eureka | 62 | 73 | 89 | 30.00 | 30.07 | +.07 | 59.7 | +3.9 | 73 | 20 | 64 | 50 | 8 | 55 | 18 | 57 | 55 | 88 | 0.02 | −0.1 | 2 | 4,144 | n. | 26 | sw. | 20 | 9 | 9 | 13 | 6.2 | 0.0 | 0.0 |
| Point Reyes | 490 | 7 | 18 | 29.44 | 29.96 | ..... | 54.8 | +0.3 | 72 | 25 | 58 | 48 | 5 | 51 | 21 | .... | .... | .... | 0.03 | ..... | 1 | 19,293 | nw. | 60 | nw. | 6 | 2 | 7 | 22 | 8.3 | 0.0 | 0.0 |
| Red Bluff | 332 | 50 | 56 | 29.54 | 29.88 | +.02 | 79.2 | −0.5 | 108 | 26 | 94 | 56 | 4 | 64 | 38 | 62 | 49 | 40 | 0.00 | 0.0 | 0 | 3,187 | se. | 16 | se. | 2 | 27 | 4 | 0 | 1.0 | 0.0 | 0.0 |
| Sacramento | 69 | 106 | 117 | 29.84 | 29.91 | +.06 | 73.5 | +0.6 | 102 | 26 | 88 | 53 | 5 | 58 | 39 | 61 | 52 | 56 | T. | 0.0 | 0 | 6,055 | s. | 24 | s. | 2 | 28 | 2 | 1 | 0.9 | 0.0 | 0.0 |
| San Francisco | 155 | 208 | 243 | 29.80 | 29.97 | +.05 | 61.7 | +2.6 | 83 | 25 | 68 | 52 | 7 | 55 | 28 | 56 | 54 | 83 | 0.01 | 0.0 | 1 | 8,135 | w. | 32 | sw. | 14 | 14 | 12 | 5 | 4.3 | 0.0 | 0.0 |
| San Jose | 141 | 12 | 110 | 29.83 | 29.98 | ..... | 67.2 | +0.5 | 97 | 25 | 80 | 48 | 2 | 54 | 40 | .... | .... | .... | 0.01 | 0.0 | 1 | 4,440 | nw. | 23 | n. | 10 | 22 | 9 | 0 | 2.3 | 0.0 | 0.0 |
| *South Pacific Coast Region.* | | | | | | | **70.4** | **−0.8** | | | | | | | | | | | **70** | **T.** | **0.0** | | | | | | | | **2.4** | | |
| Fresno | 327 | 89 | 98 | 29.54 | 29.89 | +.07 | 79.0 | −2.2 | 102 | 26 | 95 | 55 | 5 | 63 | 38 | 60 | 47 | 39 | 0.00 | 0.0 | 0 | 6,601 | nw. | 23 | nw. | 14 | 27 | 3 | 1 | 0.8 | 0.0 | 0.0 |
| Los Angeles | 338 | 159 | 191 | 29.58 | 29.93 | +.05 | 69.6 | −1.5 | 86 | 25 | 78 | 59 | 29 | 61 | 23 | 63 | 61 | 81 | T. | 0.0 | 0 | 3,693 | sw. | 21 | nw. | 24 | 20 | 9 | 2 | 3.3 | 0.0 | 0.0 |
| San Diego | 87 | 62 | 70 | 29.83 | 29.92 | +.03 | 67.8 | −0.9 | 78 | 25 | 72 | 59 | 11 | 63 | 14 | 63 | 61 | 83 | T. | 0.0 | 0 | 4,323 | w. | 18 | nw. | 27 | 18 | 10 | 3 | 3.6 | 0.0 | 0.0 |
| San Luis Obispo | 201 | 32 | 40 | 29.76 | 29.98 | +.04 | 65.0 | +1.5 | 89 | 17 | 78 | 45 | 8 | 52 | 36 | 55 | 52 | 75 | 0.00 | 0.0 | 0 | 2,785 | nw. | 14 | nw. | 19 | 27 | 4 | 0 | 1.9 | 0.0 | 0.0 |
| *West Indies.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| San Juan, P. R. | 82 | 9 | 54 | 29.94 | 30.02 | ..... | 79.9 | ..... | 88 | 19 | 84 | 71 | 11 | 75 | 14 | .... | .... | .... | 4.08 | −3.3 | 21 | 10,834 | e. | 46 | e. | 20 | 8 | 19 | 4 | 5.0 | 0.0 | 0.0 |
| *Panama Canal.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Balboa Heights | 118 | 7 | 97 | 29.73 | 29.85 | +.01 | 80.2 | 0.0 | 91 | 4 | 86 | 69 | 11 | 74 | 17 | 75 | 74 | 85 | 5.37 | −2.3 | 21 | 5,244 | nw. | 37 | n. | 5 | 0 | 9 | 22 | 7.8 | 0.0 | 0.0 |
| Colon | 36 | 7 | 97 | 29.81 | 29.85 | .00 | 81.2 | +1.1 | 89 | 5 | 86 | 71 | 27 | 76 | 14 | 77 | 76 | 86 | 15.35 | +0.3 | 30 | 7,172 | w. | 30 | w. | 25 | 0 | 12 | 19 | 8.2 | 0.0 | 0.0 |
| *Alaska.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Juneau | 80 | 11 | 54 | 29.88 | 29.97 | ..... | 58.5 | ..... | 87 | 20 | 67 | 46 | 17 | 50 | 35 | 55 | 52 | 83 | 6.86 | ..... | 13 | 3,137 | s. | 27 | nw. | 4 | 10 | 6 | 15 | 6.1 | 0.0 | 0.0 |

TABLE II.—*Data furnished by the Canadian Meteorological Service, August, 1923.*

| Stations. | Altitude above mean sea level, Jan. 1, 1919. | Pressure. | | | Temperature of the air. | | | | | | Precipitation. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Station reduced to mean of 24 hours. | Sea level reduced to mean of 24 hours. | Departure from normal. | Mean max.+mean min.÷2. | Departure from normal. | Mean maximum. | Mean minimum. | Highest. | Lowest. | Total. | Departure from normal. | Total snowfall. |
| | *Feet.* | *In.* | *In.* | *In.* | *° F.* | *° F.* | *° F.* | *° F.* | *° F.* | *° F.* | *In.* | *In.* | *In.* |
| St. Johns, N. F | 125 | | | | | | | | | | | | |
| Sydney, C. B. I | 48 | 29.89 | 29.94 | −.01 | 59.9 | −3.4 | 68.6 | 51.2 | 81 | 41 | 5.52 | +1.90 | 0.0 |
| Halifax, N. S | 88 | 29.84 | 29.94 | −.02 | 61.9 | −1.7 | 72.2 | 51.7 | 82 | 41 | 5.78 | +1.43 | 0.0 |
| Yarmouth, N. S | 65 | 29.88 | 29.95 | −.02 | 57.3 | −2.9 | 65.5 | 49.2 | 76 | 41 | 2.66 | −1.35 | 0.0 |
| Charlottetown, P. E. I | 38 | 29.85 | 29.89 | −.05 | 62.5 | −1.8 | 69.7 | 55.3 | 79 | 50 | 1.69 | −2.05 | 0.0 |
| Chatham, N. B | 28 | 29.79 | 29.82 | −.11 | 60.3 | −2.9 | 72.0 | 48.6 | 88 | 38 | 2.47 | −1.57 | 0.0 |
| Father Point, Que | 20 | 29.83 | 29.85 | −.06 | 53.0 | −2.6 | 61.7 | 44.3 | 78 | 37 | 4.43 | +1.38 | 0.0 |
| Quebec, Que | 296 | 29.59 | 29.91 | −.02 | 62.0 | −1.1 | 70.6 | 53.4 | 85 | 44 | 5.86 | +2.03 | 0.0 |
| Montreal, Que | 187 | 29.70 | 29.90 | −.05 | 65.7 | −0.7 | 74.8 | 56.6 | 88 | 44 | 3.34 | −0.23 | 0.0 |
| Stonecliffe, Ont | 489 | | | | | | | | | | | | |
| Ottawa, Ont | 236 | 29.66 | 29.92 | −.04 | 65.4 | +0.6 | 77.4 | 53.5 | 89 | 40 | 2.19 | −0.84 | 0.0 |
| Kingston, Ont | 285 | 29.64 | 29.94 | −.04 | 66.6 | −0.4 | 74.8 | 58.4 | 92 | 45 | 1.78 | −0.60 | 0.0 |
| Toronto, Ont | 379 | 29.56 | 29.95 | −.04 | 65.8 | −0.2 | 76.3 | 55.2 | 90 | 43 | 3.58 | +0.82 | 0.0 |
| Cochrane, Ont | 930 | | | | | | | | | | | | |
| White River, Ont | 1,244 | 28.63 | 29.94 | −.02 | 52.9 | −3.5 | 66.1 | 39.7 | 76 | 30 | 2.61 | −0.69 | 0.0 |
| Port Stanley, Ont | 592 | 29.36 | 30.00 | .00 | 64.6 | −1.3 | 74.5 | 54.8 | 85 | 39 | 1.06 | −1.36 | 0.0 |
| Southampton, Ont | 656 | | | | 61.3 | −2.5 | 70.9 | 51.8 | 83 | 40 | 2.73 | +0.48 | 0.0 |
| Parry Sound, Ont | 688 | 29.27 | 29.95 | −.03 | 63.2 | −0.3 | 74.9 | 51.5 | 92 | 41 | 3.87 | +1.15 | 0.0 |
| Port Arthur, Ont | 644 | 29.27 | 29.98 | +.02 | 58.0 | −1.5 | 67.4 | 48.7 | 75 | 39 | 3.41 | +0.66 | 0.0 |
| Winnipeg, Man | 760 | | | | | | | | | | | | |
| Minnedosa, Man | 1,690 | 28.20 | 29.98 | +.04 | 57.2 | −2.2 | 69.1 | 45.3 | 81 | 32 | 0.98 | −1.12 | 0.0 |
| Le Pas, Man | 860 | | | | 55.9 | | 67.6 | 44.3 | 77 | 30 | 3.45 | | 0.0 |
| Qu'Appelle, Sask | 2,115 | 27.75 | 29.98 | +.05 | 59.4 | −2.1 | 71.4 | 47.4 | 84 | 39 | 1.63 | −0.01 | 0.0 |
| Medicine Hat, Alb | 2,144 | | | | | | | | | | | | |
| Moose Jaw, Sask | 1,759 | | | | 62.5 | | 76.8 | 48.3 | 89 | 35 | 1.42 | | 0.0 |
| Swift Current, Sask | 2,392 | 27.46 | 30.05 | +.12 | 61.7 | −2.3 | 76.4 | 47.0 | 88 | 34 | 1.31 | −0.60 | 0.0 |
| Calgary, Alb | 3,428 | | | | | | | | | | | | |
| Banff, Alb | 4,521 | | | | | | | | | | | | |
| Edmonton, Alb | 2,150 | | | | | | | | | | | | |
| Prince Albert, Sask | 1,450 | 28.45 | 30.02 | +.10 | 58.6 | −0.3 | 70.1 | 47.2 | 78 | 40 | 2.91 | +0.76 | 0.0 |
| Battleford, Sask | 1,592 | 28.26 | 29.98 | +.07 | 61.2 | −1.4 | 73.7 | 48.8 | 84 | 38 | 1.58 | −0.78 | 0.0 |
| Kamloops, B. C | 1,262 | | | | | | | | | | | | |
| Victoria, B. C | 230 | 29.78 | 30.03 | +.02 | 60.9 | +2.2 | 68.8 | 53.1 | 81 | 49 | 0.80 | +0.20 | 0.0 |
| Barkerville, B. C | 4,180 | | | | | | | | | | | | |
| Triangle Island, B. C | 680 | | | | | | | | | | | | |
| Prince Rupert, B. C | 170 | | | | | | | | | | | | |
| Hamilton, Ber | 151 | | | | | | | | | | | | |

## SEISMOLOGICAL REPORTS FOR AUGUST, 1923.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, October 3, 1923.]

TABLE 1.—*Noninstrumental earthquake reports, August, 1923.*

| Day. | Approximate time, Greenwich civil. | Station. | Approximate latitude. | Approximate longitude. | Intensity Rossi-forel. | Number of shocks. | Duration. | Sounds. | Remarks. | Observer. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | CALIFORNIA. | | | | | | | | |
| 1923. | *H. m.* | | ° ′ | ° ′ | | | *Sec.* | | | |
| Aug. 25 | 11 24 | Salinas | 36 41 | 121 39 | 3 | 2 | 2 | None | Felt by many | Dr. E. D. Eddy. |
| | 11 25 | Spreckels | 36 38 | 121 36 | 5 | 1 | 30 | ....do | ....do | Wm. Suttie. |

TABLE 2.—*Instrumental seismological reports, August, 1923.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols and description of stations, see REVIEW for January, 1923.]

| Date. | Character. | Phase. | Time. | Period T. | Amplitude. AE | Amplitude. AN | Distance. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| **ALASKA. *U. S. C. & G. S. Magnetic Observatory, Sitka.*** | | | | | | | | |
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Aug. 28 | ..... | *O*..... | 23 14 34 | ..... | ..... | ..... | 4,280 | |
| | | $P_E$..... | 23 22 16 | 8 | ..... | ..... | ..... | |
| | | $P_N$..... | 23 22 08 | 8 | ..... | ..... | ..... | |
| | | S..... | 23 28 15 | 12 | ..... | ..... | ..... | |
| | | SR2... | 23 31 16 | 17 | ..... | ..... | ..... | |
| | | $eL_E$... | 23 32 42 | 30 | ..... | ..... | ..... | |
| | | $eL_N$... | 23 34 18 | 28 | ..... | ..... | ..... | |
| | | $e_E$..... | 23 36 08 | 12 | ..... | ..... | ..... | |
| | | $e_N$..... | 23 36 00 | 12 | ..... | ..... | ..... | |
| | | $M_E$.... | 23 36 28 | 12 | *500 | ..... | ..... | |
| | | $M_N$.... | 23 36 37 | 11 | ..... | *400 | ..... | |
| | | C..... | 23 42 .. | 10 | ..... | ..... | ..... | |
| | | $F_E$.... | 24 35 .. | 10 | ..... | ..... | ..... | |
| | | $F_N$.... | 24 31 .. | 10 | ..... | ..... | ..... | |
| **ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*** | | | | | | | | |
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Aug. 28 | ..... | *O*..... | 23 14 35 | ..... | ..... | ..... | 1,120 | Recorded on magnetograph. |
| | | $P_E$.... | 23 17 03 | 2 | ..... | ..... | ..... | |
| | | $P_N$.... | 23 17 00 | ..... | ..... | ..... | ..... | |
| | | S..... | 23 19 00 | 4 | ..... | ..... | ..... | |
| | | $L_E$.... | 23 19 18 | ..... | ..... | ..... | ..... | |
| | | $L_N$.... | 23 19 20 | ..... | ..... | ..... | ..... | |
| | | $M_E$.... | 23 19 39 | 15 | *32,000 | ..... | ..... | |
| | | $M_N$.... | 23 20 19 | 8 | ..... | *9,000 | ..... | |
| | | $C_E$.... | 23 27 .. | 6 | ..... | ..... | ..... | |
| | | $C_N$.... | 23 27 .. | 8 | ..... | ..... | ..... | |
| 29 | ..... | $F_E$.... | 0 22 .. | 8 | ..... | ..... | ..... | |
| | | $F_N$.... | 23 47 .. | 7 | ..... | ..... | ..... | |
| **CALIFORNIA. *Theosophical University, Point Loma.*** | | | | | | | | |
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Aug. 2 | ..... | ..... | 15 00 00 | ..... | 50 | 50 | ..... | Tremors during preceding 24 hours. |
| 27 | ..... | ..... | ..... | ..... | 100 | 100 | ..... | |
| 29 | ..... | ..... | ..... | ..... | 50 | 50 | ..... | |
| **COLORADO. *Regis College, Denver.*** | | | | | | | | |
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Aug 28 | ..... | $P_E$.... | 23 18 30 | ..... | ..... | ..... | ..... | Instrument apparently did not work satisfactorily. |
| | | $P_N$.... | 23 20 40 | ..... | ..... | ..... | ..... | |
| | | $S_E$.... | 23 18 30 | ..... | ..... | ..... | ..... | |
| | | $S_N$.... | 23 20 40 | ..... | ..... | ..... | ..... | |
| | | L..... | 23 23 30 | 10-11 | ..... | ..... | ..... | |
| | | M..... | 23 30 .. | ..... | *12,000 | *14,000 | ..... | |
| | | C..... | 23 39 .. | ..... | ..... | ..... | ..... | |
| 29 | ..... | L..... | 0 03 .. | ..... | ..... | ..... | ..... | |
| **DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*** | | | | | | | | |
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Aug 1 | ..... | i..... | 8 38 05 | ..... | ..... | ..... | ..... | |
| | | eL..... | 8 57 .. | ..... | ..... | ..... | ..... | |
| | | F..... | 9 .. .. | ..... | ..... | ..... | ..... | |
| 8 | ..... | e..... | 12 07 40 | ..... | ..... | ..... | ..... | |
| | | PR1... | 12 08 40 | ..... | ..... | ..... | ..... | |
| | | S..... | 12 13 20 | ..... | ..... | ..... | ..... | |
| 8 | ..... | eL..... | 12 46 .. | ..... | ..... | ..... | ..... | |
| | | F..... | 12 54 .. | ..... | ..... | ..... | ..... | |
| 28 | ..... | P..... | 23 21 22 | ..... | ..... | ..... | 2,400 | |
| | | S..... | 23 25 18 | ..... | ..... | ..... | ..... | |
| | | eL?.... | 23 28 30 | ..... | ..... | ..... | ..... | L nowhere distinct. |
| | | M1..... | 23 32 30 | ..... | *20,000 | ..... | ..... | |
| | | M2..... | 23 34 30 | ..... | *20,000 | ..... | ..... | |
| 29 | ..... | F..... | 0 20 .. | ..... | ..... | ..... | ..... | |
| **ILLINOIS. *U. S. Weather Bureau, Chicago.*** | | | | | | | | |
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Aug. 1 | ..... | i..... | 8 38 45 | ..... | ..... | ..... | ..... | |
| | | eL..... | 8 55 .. | ..... | ..... | ..... | ..... | |
| | | F..... | 9 15 .. | ..... | ..... | ..... | ..... | |

* Trace amplitude.

| Date. | Character. | Phase. | Time. | Period T. | Amplitude. AE | Amplitude. AN | Distance. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| **ILLINOIS. *U. S. Weather Bureau, Chicago*—Continued.** | | | | | | | | |
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Aug. 2 | ..... | e..... | 9 39 10 | ..... | ..... | ..... | ..... | |
| | | F..... | 10 .. .. | ..... | ..... | ..... | ..... | |
| 3 | ..... | e..... | 10 42 50 | ..... | ..... | ..... | ..... | |
| | | eL..... | 10 49 25 | ..... | ..... | ..... | ..... | |
| | | F..... | 11 05 .. | ..... | ..... | ..... | ..... | |
| 4 | ..... | e..... | 17 02 50 | ..... | ..... | ..... | ..... | |
| | | eL..... | 17 11 30 | 15 | ..... | ..... | ..... | |
| | | F..... | 17 40 .. | ..... | ..... | ..... | ..... | |
| 8 | ..... | iP..... | 12 08 39 | ..... | ..... | ..... | 4,000 | |
| | | PR1... | 12 10 07 | ..... | ..... | ..... | ..... | |
| | | iS..... | 12 14 23 | ..... | ..... | ..... | ..... | |
| | | L..... | 12 17 10 | ..... | ..... | ..... | ..... | |
| | | F?..... | ..... | ..... | ..... | ..... | ..... | Lost in succeeding quake. |
| 8 | ..... | e..... | 12 28 *ca* | ..... | ..... | ..... | ..... | |
| | | L..... | 12 51 .. | 22 | ..... | ..... | ..... | |
| | | L..... | 12 53 .. | 16 | ..... | ..... | ..... | |
| | | F..... | 14 *ca.* | ..... | ..... | ..... | ..... | |
| 10 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Quake about 23*h.*, of about an hour's duration; no time marks. |
| 11 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Quake about 1*h.*30*m.*; duration 1½ hrs.; no time marks. |
| 12 | ..... | e..... | 10 33 45 | ..... | ..... | ..... | ..... | |
| | | eL..... | 10 55 .. | ..... | ..... | ..... | ..... | |
| | | L..... | 11 06 .. | 20 | ..... | ..... | ..... | |
| | | L..... | 11 11 .. | 16 | ..... | ..... | ..... | |
| | | F..... | 12 *ca.* | ..... | ..... | ..... | ..... | |
| 15 | ..... | e..... | 7 46 30 | ..... | ..... | ..... | ..... | May not be seismic. |
| | | L..... | 7 48 .. | 18 | ..... | ..... | ..... | |
| | | F..... | 8 *ca.* | ..... | ..... | ..... | ..... | |
| 16 | ..... | P?..... | 20 44 15 | ..... | ..... | ..... | ..... | |
| | | eL..... | 21 05 .. | ..... | ..... | ..... | ..... | |
| | | F..... | 21 30 *ca* | ..... | ..... | ..... | ..... | |
| 17 | ..... | e..... | 1 23 33 | ..... | ..... | ..... | ..... | |
| | | eL..... | 1 45 .. | 16 | ..... | ..... | ..... | |
| | | F..... | 2 15 *ca* | ..... | ..... | ..... | ..... | |
| 17 | ..... | e?..... | 12 40 55 | ..... | ..... | ..... | ..... | |
| | | eL..... | 13 04 .. | ..... | ..... | ..... | ..... | |
| | | L..... | 13 10 .. | 16 | ..... | ..... | ..... | |
| | | F..... | 14 *ca* .. | ..... | ..... | ..... | ..... | |
| 19 | ..... | e..... | ..... | ..... | ..... | ..... | ..... | Lost, changing sheets. |
| | | L..... | 12 25 .. | 18 | ..... | ..... | ..... | |
| | | L..... | 12 39 .. | 16 | ..... | ..... | ..... | |
| | | F..... | 14 10 *ca* | ..... | ..... | ..... | ..... | |
| 23 | ..... | P..... | 5 28 11 | ..... | ..... | ..... | 4,200 | |
| | | S?..... | 5 34 06 | ..... | ..... | ..... | ..... | |
| | | L?..... | 5 38 50 | ..... | ..... | ..... | ..... | |
| | | L..... | 5 42 20 | 16 | ..... | ..... | ..... | |
| | | F..... | 6 50 *ca* | ..... | ..... | ..... | ..... | |
| 28 | ..... | iP..... | 23 20 35 | ..... | ..... | ..... | 2,600 | |
| | | iS..... | 23 24 48 | ..... | ..... | ..... | ..... | |
| | | L?..... | 23 27 45 | ..... | ..... | ..... | ..... | L nowhere clearly defined. |
| | | M..... | 23 29 .. | ..... | *28000 | ..... | ..... | |
| 29 | ..... | F..... | 2 *ca* .. | ..... | ..... | ..... | ..... | |
| **MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*** | | | | | | | | |
| 1923. | | | *H. m. s.* | *Sec.* | *μ* | *μ* | *Km.* | |
| Aug. 28 | ..... | $e_N$..... | 23 24 06 | 3 | ..... | ..... | (3,600) | Preliminary phases barely perceptible. Epicenter probably off end of Lower California. |
| | | $e_E$..... | 23 25 11 | ..... | ..... | ..... | ..... | |
| | | $eS_E$... | 23 26 27 | ..... | ..... | ..... | ..... | |
| | | $SR1_E$. | 23 28 09 | ..... | ..... | ..... | ..... | |
| | | $SR1_N$. | 23 28 20 | 5 | ..... | ..... | ..... | |
| | | $eL_E$... | 23 31 07 | 5 | ..... | ..... | ..... | |
| | | $eL_N$... | 23 30 52 | 6 | ..... | ..... | ..... | |
| | | $e_N$..... | 23 31 16 | 20 | ..... | ..... | ..... | |
| | | $M_E$.... | 23 34 30 | 10 | *900 | ..... | ..... | |
| | | $M_N$.... | 23 32 44 | 12 | ..... | *10000 | ..... | |
| | | C..... | 23 36 .. | 7 | ..... | ..... | ..... | |
| 29 | ..... | $F_E$.... | 0 05 .. | 10 | ..... | ..... | ..... | |
| | | $F_N$.... | 0 08 .. | 10 | ..... | ..... | ..... | |

* Trace amplitude.

TABLE 2.—*Instrumental seismological reports, August, 1923*—Continued.

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Aug. 8 | ..... | $eP_E$ | 12 03 25 | ..... | ..... | ..... | ..... | *No earthquakes recorded in July.* |
| | | $iP_N$ | 12 03 17 | 2 | ..... | ..... | ..... | |
| | | $e_E$ | 12 04 19 | 5 | ..... | ..... | ..... | |
| | | $e_N$ | 12 04 03 | 6 | ..... | ..... | ..... | |
| | | $e_E$ | 12 05 09 | ..... | ..... | ..... | ..... | |
| | | $e_N$ | 12 05 10 | ..... | ..... | ..... | ..... | |
| | | M | 12 05 16 | 8 | *200 | *200 | ..... | |
| | | $F_E$ | 12 14 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 12 16 .. | ..... | ..... | ..... | ..... | |
| 28 | ..... | $eP_E$ | 23 22 46 | 5 | ..... | ..... | (4,700) | Barely perceptible; nothing on N. Probably off end of Lower California. |
| | | $e_E$ | 23 31 22 | ..... | ..... | ..... | ..... | |
| | | $eL_E$ | 23 36 54 | 30 | *50 | ..... | ..... | |
| | | $F_E$ | 23 52 .. | ..... | ..... | ..... | ..... | |

CANAL ZONE. *Panama Canal, Balboa Heights.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Aug. 7 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Very slight tremors from 12:08 to 12:20. |
| 28 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Slight tremors from distant disturbance between 11:20 and 12:00. |

VERMONT. *U. S. Weather Bureau, Northfield.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Aug. 28 | ..... | e | 23 20 40 | ..... | ..... | ..... | ..... | |
| | | S? | 23 27 22 | ..... | ..... | ..... | ..... | |
| | | Mn | 23 35 .. | ..... | ..... | *30000 | ..... | |
| 29 | ..... | F | 0 10 .. | ..... | ..... | ..... | ..... | |

CANADA. *Dominion Observatory, Ottawa.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Aug. 1 | ..... | eL | 5 24 .. | ..... | ..... | ..... | ..... | No. 17 only. |
| | | L | 5 34 .. | 20 | ..... | ..... | ..... | |
| | | L | 5 55 .. | 16 | ..... | ..... | ..... | |
| | | L | 6 30 .. | 16 | ..... | ..... | ..... | |
| | | F | 7 00 .. | ..... | ..... | ..... | ..... | |
| 1 | ..... | i | 8 37 20 | ..... | ..... | ..... | ..... | Very slight traces, probably not seismic, appear at 8:28. |
| | | i | 8 37 47 | ..... | ..... | ..... | ..... | |
| | | eL | 8 53 .. | 14 | ..... | ..... | ..... | |
| | | F | 9 15 .. | ..... | ..... | ..... | ..... | |
| 2 | ..... | e | 9 45 24 | ..... | ..... | ..... | ..... | |
| | | eL | 9 48 12 | 10 | ..... | ..... | ..... | |
| | | L | 9 52 .. | 6 | ..... | ..... | ..... | |
| | | F | 9 55 .. | ..... | ..... | ..... | ..... | |
| 4 | ..... | eL | 17 13 *to* | 20 | ..... | ..... | ..... | Small sinusoidal L waves on No. 17 only. |
| | | L | 17 55 .. | 10 | ..... | ..... | ..... | |
| | | F | 18 00 .. | ..... | ..... | ..... | ..... | |
| 8 | ..... | eL | 9 05 .. | ..... | ..... | ..... | ..... | No. 17 only. |
| | | F | 9 23 .. | ..... | ..... | ..... | ..... | |
| 5 | ..... | e | 11 04 *to* | ..... | ..... | ..... | ..... | Very short periods small amplitudes .. L waves(?). |
| | | L? | 11 15 .. | 5 | ..... | ..... | ..... | |
| | | F | 11 18 .. | ..... | ..... | ..... | ..... | |
| 8 | ..... | *O* | (12 01 48) | ..... | ..... | ..... | (3,500) | |
| | | iP? | 12 08 28 | ..... | ..... | ..... | ..... | |
| | | i | 12 09 51 | ..... | ..... | ..... | ..... | |
| | | eS? | 12 13 45 | ..... | ..... | ..... | ..... | |
| | | eL | 12 16 30 | ..... | ..... | ..... | ..... | |
| | | L | 12 24 .. | 14 | ..... | ..... | ..... | |
| | | F | ..... | ..... | ..... | ..... | ..... | Lost in succeeding quake. |
| 8 | ..... | eP?v | 12 27 39 | ..... | ..... | ..... | ..... | P lost in preceding quake in all records except vertical. |
| | | e | 12 35 48 | ..... | ..... | ..... | ..... | |
| | | eL?17 | 12 42 42 | ..... | ..... | ..... | ..... | |
| | | L17 | 12 45 36 | 30 | ..... | ..... | ..... | |
| | | L17 | 12 51 .. | 16 | ..... | ..... | ..... | |
| | | F | 13 50 *ca* | ..... | ..... | ..... | ..... | |
| 10 | ..... | L | 3 08 *to* | ..... | ..... | ..... | ..... | No. 17 only. |
| | | F | 3 18 .. | ..... | ..... | ..... | ..... | |
| 10 | ..... | eL | 16 45 .. | 25 | ..... | ..... | ..... | Sinusoidal L waves on No. 17 only; heavy micros. |
| | | L | 16 55 .. | 30 | ..... | ..... | ..... | |
| | | L | 17 05 .. | 25 | ..... | ..... | ..... | |
| | | F | 17 20 .. | ..... | ..... | ..... | ..... | |
| 10 | ..... | eL | 23 08 .. | ..... | ..... | ..... | ..... | Sinusoidal L waves, No. 17; micros heavy. |
| | | L | 23 15 *to* | 27 | ..... | ..... | ..... | |
| | | L | 23 45 .. | 15 | ..... | ..... | ..... | |
| 11 | ..... | F | 0 10 .. | ..... | ..... | ..... | ..... | |

* Trace amplitude.

CANADA. *Dominion Observatory, Ottawa*—Continued.

| 1923. | | | R. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Aug. 11 | ..... | e | 1 27 42 | ..... | ..... | ..... | ..... | Sinusoidal L waves, No. 17; micros heavy. |
| | | i | 1 38 .. | ..... | ..... | ..... | ..... | |
| | | eL? | 1 51 30 | 40 | ..... | ..... | ..... | |
| | | L | 1 59 .. | 26 | ..... | ..... | ..... | |
| | | L | 2 05 .. | 23 | ..... | ..... | ..... | |
| | | L | 2 20 .. | 16 | ..... | ..... | ..... | |
| | | L | 2 38 .. | 13 | ..... | ..... | ..... | |
| | | F | 3 15 .. | ..... | ..... | ..... | ..... | |
| 12 | ..... | e? | 6 55 .. | ..... | ..... | ..... | ..... | No. 17 only. |
| | | e | 7 04 *to* | ..... | ..... | ..... | ..... | |
| | | e | 7 12 .. | ..... | ..... | ..... | ..... | |
| | | L | 7 13 *to* | ..... | ..... | ..... | ..... | |
| | | L | 7 28 .. | 14 | ..... | ..... | ..... | |
| | | F | 7 35 .. | ..... | ..... | ..... | ..... | |
| 12 | ..... | e? | 10 24 46 | ..... | ..... | ..... | ..... | |
| | | e | 10 25 12 | ..... | ..... | ..... | ..... | |
| | | eL? | 10 54 .. | ..... | ..... | ..... | ..... | |
| | | L | 11 01 30 | 28 | ..... | ..... | ..... | |
| | | L | *to* 35 .. | 12 | ..... | ..... | ..... | |
| | | F | 12 *ca* .. | ..... | ..... | ..... | ..... | |
| 12 | ..... | eL | 17 42 *to* | 14 | ..... | ..... | ..... | |
| | | F | 18 00 .. | ..... | ..... | ..... | ..... | |
| 16 | ..... | e | 20 44 40 | ..... | ..... | ..... | ..... | Sinusoidal L waves; record on No. 17 only. |
| | | e? | 20 53 48 | ..... | ..... | ..... | ..... | |
| | | eL | 21 03 .. | 22 | ..... | ..... | ..... | Small amplitude. |
| | | L | 21 12 .. | 20 | ..... | ..... | ..... | |
| | | L | 21 20 .. | ..... | ..... | ..... | ..... | |
| | | F | 22 *ca* .. | ..... | ..... | ..... | ..... | |
| 17 | ..... | i | 1 25 31 | ..... | ..... | ..... | ..... | No. 17 only; sinusoidal L waves of small amplitude. |
| | | e | 1 24 .. | ..... | ..... | ..... | ..... | |
| | | eL | 1 45 30 | 18 | ..... | ..... | ..... | |
| | | F | 2 15 .. | ..... | ..... | ..... | ..... | |
| 17 | ..... | eL | 4 27 *to* | 20 | ..... | ..... | ..... | No. 17 only. |
| | | F | 5 *ca* .. | ..... | ..... | ..... | ..... | |
| 17 | ..... | L | 12 14 *to* | 20 | ..... | ..... | ..... | Do. |
| | | L | 13 10 .. | ..... | ..... | ..... | ..... | |
| | | F | ..... | ..... | ..... | ..... | ..... | Lost in changing sheets. |
| 19 | ..... | e | 12 56 18 | ..... | ..... | ..... | ..... | No. 17 only. |
| | | i | 13 01 28 | ..... | ..... | ..... | ..... | |
| | | eL? | 13 18 30 | ..... | ..... | ..... | ..... | |
| | | L | 13 25 .. | 24 | 6 | ..... | ..... | |
| | | L | 13 35 .. | 18 | ..... | ..... | ..... | |
| | | L | 13 46 .. | 16 | ..... | ..... | ..... | |
| | | F | 14 15 .. | ..... | ..... | ..... | ..... | |
| 20 | ..... | L | 19 20 *to* | 20 | 1 | ..... | ..... | |
| | | F | 20 10 .. | ..... | ..... | ..... | ..... | |
| 23 | ..... | *O* | (5 21 31) | ..... | ..... | ..... | (5,060) | Only traces on Bosch instruments. |
| | | eP | 5 30 03 | ..... | ..... | ..... | ..... | |
| | | eS | (5 36 48) | ..... | ..... | ..... | ..... | |
| | | eL | 5 42 54 | 18 | 6 | ..... | ..... | |
| | | L | 5 51 .. | 14 | ..... | ..... | ..... | |
| | | F | 7 *ca* .. | ..... | ..... | ..... | ..... | |
| 26 | ..... | L | (14 30).. | 22 | 15 | ..... | ..... | Small sinusoidal waves easily read; time marks uncertain. |
| | | F | (15 15).. | ..... | ..... | ..... | ..... | |
| 28 | ..... | *O* | 23 15 17 | ..... | ..... | ..... | 3,470 | |
| | | iP | 23 21 55 | ..... | ..... | ..... | ..... | Period at M may have been greater than 8 sec.; difficult of determination. |
| | | iS | 23 27 10 | ..... | ..... | ..... | ..... | |
| | | eL | 23 31 .. | ..... | ..... | ..... | ..... | |
| | | M | 23 34 .. | (8) | (307) | ..... | ..... | |
| | | L | 23 49 .. | 14 | 58 | ..... | ..... | |
| 29 | ..... | L | 0 18 .. | 11 | 8 | ..... | ..... | |
| | | L | 0 50 .. | 11 | 1 | ..... | ..... | |
| | | F | 2 *ca* .. | ..... | ..... | ..... | ..... | |
| 30 | ..... | L | (15 00).. | 18 | 1 | ..... | ..... | On No. 17 only; time marks uncertain. |
| | | F | (15 45).. | ..... | ..... | ..... | ..... | |

CANADA. *Meteorological Service of Canada, Victoria.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| Aug. 1 | ..... | P | 8 40 00 | 5 | ..... | ..... | ..... | |
| N | ..... | M | 9 08 18 | 20 | 1 | ..... | ..... | |
| | ..... | F | 9 22 40 | ..... | ..... | ..... | ..... | |
| 2 | ..... | P | 9 26 20 | 4 | ..... | ..... | ..... | |
| | ..... | S | 9 28 00 | 8 | ..... | ..... | ..... | |
| | ..... | L | 9 29 40 | 10 | ..... | ..... | ..... | |
| N | ..... | M | 9 32 04 | 7 | 5 | ..... | 920 | |
| | ..... | F | 9 59 00 | ..... | ..... | ..... | ..... | |
| 2 | ..... | M | 10 02 25 | 10 | ..... | ..... | ..... | |
| N | ..... | F | 10 14 18 | ..... | 1 | ..... | ..... | |
| 3 | ..... | P | 10 29 15 | 8 | ..... | ..... | ..... | E–W H. P. installed on new pier on Aug. 6. |
| | ..... | L | 10 35 19 | 10 | ..... | ..... | ..... | |
| N | ..... | M | 10 33 31 | 10 | 2 | ..... | ..... | |
| | ..... | F | 11 04 59 | ..... | ..... | ..... | ..... | |
| 7 | ..... | L | 8 14 50 | 25 | ..... | ..... | ..... | NS. not shown. |
| E | ..... | M | 8 16 22 | 18 | ..... | 2 | ..... | |
| | ..... | F | 8 28 30 | ..... | ..... | ..... | ..... | |

TABLE 1.—*Instrumental seismological reports, August, 1923*—Continued.

CANADA. *Meteorological Service of Canada, Victoria*—Continued.

| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
|---|---|---|---|---|---|---|---|---|
| Aug. 7 | ..... | L..... | 8 37 48 | 12 | ..... | ..... | ..... | |
| E | ..... | M..... | 8 38 04 | 10 | ..... | 1 | ..... | |
| | ..... | F..... | 8 46 00 | ..... | ..... | ..... | ..... | |
| | ..... | L..... | 8 37 50 | 12 | ..... | ..... | ..... | |
| N | ..... | M..... | 8 38 40 | 10 | 1 | ..... | ..... | |
| | ..... | F..... | 8 45 00 | ..... | ..... | ..... | ..... | |
| 7 | ..... | L..... | 15 25 00 | 20 | ..... | ..... | ..... | Not shown on N-S. |
| E | ..... | M..... | 15 31 40 | 18 | ..... | 1 | ..... | |
| | ..... | F..... | 15 45 00 | ..... | ..... | ..... | ..... | |
| 8 | ..... | P..... | 10 50 08 | 5 | ..... | ..... | ..... | |
| | ..... | L..... | 10 54 08 | 10 | ..... | ..... | ..... | |
| E | ..... | M..... | 10 54 33 | 8 | ..... | 1 | ..... | |
| | ..... | F..... | 11 04 48 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 10 50 08 | 5 | ..... | ..... | ..... | |
| | ..... | L..... | 10 54 02 | 8 | ..... | ..... | ..... | |
| N | ..... | M..... | 10 54 28 | 8 | 1 | ..... | ..... | |
| | ..... | F..... | 11 03 58 | ..... | ..... | ..... | ..... | |
| 8 | ..... | P..... | 12 11 43 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 12 20 46 | 10 | ..... | ..... | ..... | |
| E | ..... | L..... | 12 32 18 | 35 | ..... | ..... | ..... | |
| | ..... | M..... | 13 08 08 | 20 | ..... | 20 | 7,660 | |
| | ..... | F..... | 14 06 36 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 12 11 45 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 12 20 02 | 10 | ..... | ..... | ..... | |
| N | ..... | L..... | 12 33 16 | 10 | ..... | ..... | ..... | |
| | ..... | M..... | 13 04 53 | 15 | 4 | ..... | 7,550 | |
| | ..... | F..... | 14 03 48 | ..... | ..... | ..... | ..... | |
| 10 | ..... | L..... | 3 13 16 | 12 | ..... | ..... | ..... | |
| E | ..... | M..... | 3 18 01 | 15 | ..... | 2 | ..... | |
| | ..... | F..... | 3 26 26 | ..... | ..... | ..... | ..... | |
| N | ..... | M..... | 3 19 41 | 12 | 1 | ..... | ..... | |
| 10 | ..... | P..... | 22 38 33 | 6 | ..... | ..... | ..... | |
| | ..... | L..... | 22 56 25 | 30 | ..... | ..... | ..... | |
| E | ..... | M..... | 22 59 25 | 15 | ..... | 4 | ..... | |
| | ..... | F..... | 23 35 40 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 22 38 45 | 8 | ..... | ..... | ..... | |
| N | ..... | M..... | 22 58 35 | 12 | ..... | ..... | ..... | |
| | ..... | F..... | 23 23 25 | ..... | 2 | ..... | ..... | |
| 11 | ..... | P..... | 1 12 55 | 8 | ..... | ..... | ..... | |
| | ..... | S..... | 1 22 07 | 12 | ..... | ..... | ..... | |
| E | ..... | L..... | 1 43 05 | 25 | ..... | ..... | ..... | |
| | ..... | M..... | 1 59 37 | 20 | ..... | 3 | 7,840 | |
| | ..... | F..... | 3 24 55 | ..... | ..... | ..... | ..... | |
| | ..... | L..... | 1 37 30 | 25 | ..... | ..... | ..... | |
| N | ..... | S..... | ?1 23 00 | 12 | ..... | ..... | ..... | |
| 12 | ..... | P..... | 10 18 29 | 6 | ..... | ..... | ..... | |
| | ..... | S..... | 10 28 43 | 10 | ..... | ..... | ..... | |
| E | ..... | M..... | 11 01 53 | 18 | ..... | 4 | 9,060 | |
| | ..... | F..... | 11 58 53 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 10 18 31 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 10 28 48 | 8 | ..... | ..... | ..... | |
| N | ..... | M..... | 11 02 41 | 14 | 2 | ..... | 9,120 | |
| | ..... | F..... | 11 58 53 | ..... | ..... | ..... | ..... | |
| 15 | ..... | S..... | 7 12 01 | 5 | ..... | ..... | ..... | |
| | ..... | L..... | 7 24 56 | 20 | ..... | ..... | ..... | |
| | E | M..... | 7 36 31 | 20 | ..... | 3 | ..... | |
| | ..... | F..... | 8 13 26 | ..... | ..... | ..... | ..... | |
| N | ..... | S..... | 7 12 08 | 10 | ..... | ..... | ..... | |
| 15 | ..... | L..... | 18, 43 28 | 5 | ..... | ..... | ..... | |
| E | ..... | M..... | 18 48 48 | 5 | ..... | 2 | ..... | |
| | ..... | F..... | 18 52 36 | ..... | ..... | ..... | ..... | |
| N | ..... | P..... | 18 48 36 | 5 | ..... | ..... | ..... | |
| | ..... | L..... | 18 48 51 | 8 | 1 | ..... | ..... | |
| 16 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Clock stopped on E-W. |
| | ..... | P..... | 20 39 45 | 8 | ..... | ..... | ..... | |
| N | ..... | M..... | 21 06 45 | 12 | 1 | ..... | ..... | |
| | ..... | F..... | 21 45 15 | ..... | ..... | ..... | ..... | |
| 17 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Clock stopped on E-W. |
| | ..... | P..... | 1 17 55 | 8 | ..... | ..... | ..... | |
| N | ..... | S..... | 1 28 27 | 10 | ..... | ..... | ..... | |
| | ..... | L..... | 1 46 35 | 20 | ..... | ..... | ..... | |
| | ..... | M..... | 1 51 35 | 18 | 2 | ..... | 9,440 | |
| | ..... | F..... | 2 39 07 | ..... | ..... | ..... | ..... | |
| 17 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Clock stopped on E-W. |
| | ..... | P..... | 12 33 54 | 10 | ..... | ..... | ..... | |
| | ..... | S..... | 12 42 12 | 12 | ..... | ..... | ..... | |
| | ..... | L..... | 12 46 54 | 30 | ..... | ..... | ..... | |
| N | ..... | M..... | 12 49 39 | 18 | 3 | ..... | 6,780 | |
| | ..... | F..... | 13 35 54 | ..... | ..... | ..... | ..... | |
| 19 | ..... | P..... | 12 47 09 | 6 | ..... | ..... | ..... | |
| | ..... | L..... | 13 05 59 | 25 | ..... | ..... | ..... | |
| E | ..... | M..... | 13 12 17 | 22 | ..... | 7 | ..... | |
| | ..... | F..... | 13 59 59 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 12 47 59 | 5 | ..... | ..... | ..... | |
| | ..... | L..... | 13 04 09 | 20 | ..... | ..... | ..... | |
| N | ..... | M..... | 13 13 04 | 20 | 4 | ..... | ..... | |
| | ..... | F..... | 13 59 59 | ..... | ..... | ..... | ..... | |

CANADA. *Meteorological Service of Canada, Victoria*—Continued.

| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
|---|---|---|---|---|---|---|---|---|
| Aug. 23 | ..... | P..... | 5 22 46 | 5 | ..... | ..... | ..... | Clock trouble with N-S. |
| | ..... | S..... | 5 29 17 | 10 | ..... | ..... | ..... | |
| E | ..... | L..... | 5 38 01 | 20 | ..... | ..... | ..... | |
| | ..... | M..... | 5 41 53 | 20 | ..... | 12 | 4,790 | |
| | ..... | F..... | 7 10 06 | ..... | ..... | ..... | ..... | |
| 28 | ..... | P..... | 23 20 38 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 23 25 18 | 10 | ..... | ..... | ..... | |
| | ..... | L..... | 23 27 58 | 22 | ..... | ..... | ..... | |
| E | ..... | M..... | 23 31 38 | 20 | ..... | 253 | 2,960 | S. California. |
| | ..... | F..... | 2 20 48 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 23 20 38 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 23 25 30 | 10 | ..... | ..... | ..... | |
| N | ..... | L..... | 23 27 58 | 22 | ..... | ..... | ..... | |
| | ..... | M..... | 23 33 38 | 10 | 72 | ..... | 3,120 | S. California. |
| | ..... | F..... | 2 16 08 | ..... | ..... | ..... | ..... | |
| 31 | ..... | P..... | 11 40 36 | 8 | ..... | ..... | ..... | |
| | ..... | L..... | 11 58 56 | 20 | ..... | ..... | ..... | |
| E | ..... | M..... | 12 12 16 | 15 | ..... | 2 | ..... | |
| | ..... | F..... | 12 43 36 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 11 40 56 | 8 | ..... | ..... | ..... | |
| | ..... | L..... | 11 54 56 | 20 | ..... | ..... | ..... | |
| N | ..... | M..... | (?) | ..... | 1 | ..... | ..... | |

Reports for August, 1923, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.
DISTRICT OF COLUMBIA. *Georgetown University*, Washington.
HAWAII. *U. S. C. & G. S. Magnetic Observatory*, Honolulu.
MASSACHUSETTS. *Harvard University*, Cambridge.
MISSOURI. *St. Louis University*, St. Louis.
NEW YORK. *Cornell University*, Ithaca.

The station at *Fordham University*, New York, N. Y., was closed for repairs until September 10.

TABLE 3.—*Late reports (instrumental).*

ALASKA. *U. S. C. & G. S. Magnetic Observatory, Sitka.*

| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
|---|---|---|---|---|---|---|---|---|
| July 7 | ..... | $e_E$..... | 6 11 46 | ..... | ..... | ..... | ..... | |
| | | $e_N$..... | 6 11 32 | ..... | ..... | ..... | ..... | |
| | | $M_E$..... | 6 12 14 | 8 | *200 | ..... | ..... | |
| | | $M_N$..... | 6 12 14 | 8 | ..... | *200 | ..... | |
| | | $F_E$..... | 6 20 .. | ..... | ..... | ..... | ..... | |
| 12 | ..... | $e_E$..... | 3 46 47 | ..... | ..... | ..... | ..... | |
| | | $L_E$..... | 3 51 57 | ..... | ..... | ..... | ..... | |
| | | $L_N$..... | 3 52 19 | 10 | ..... | ..... | ..... | |
| | | $F_E$..... | 4 35 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$..... | 4 24 .. | ..... | ..... | ..... | ..... | |
| 13 | ..... | *O*..... | 11 13 38 | ..... | ..... | ..... | 7,250 | |
| | | $P_N$..... | 11 24 19 | ..... | ..... | ..... | ..... | |
| | | $S_E$..... | 11 33 15 | ..... | ..... | ..... | ..... | |
| | | $S_N$..... | 11 33 01 | ..... | ..... | ..... | ..... | |
| | | $PS_N$..... | 11 33 29 | ..... | ..... | ..... | ..... | |
| | | $L1_E$..... | 11 49 17 | ..... | ..... | ..... | ..... | |
| | | $L2_E$..... | 11 50 47 | 23 | *100 | ..... | ..... | |
| | | $M_N$..... | 11 54 23 | 18 | ..... | *100 | ..... | |
| | | $F_E$..... | 12 20 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$..... | 12 25 .. | ..... | ..... | ..... | ..... | |
| 17 | ..... | e..... | 1 07 06 | ..... | ..... | ..... | ..... | |
| | | $M_E$..... | 1 08 43 | 9 | *100 | ..... | ..... | |
| | | $M_N$..... | 1 08 51 | 9 | ..... | *100 | ..... | |
| | | $F_E$..... | 1 19 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$..... | 1 17 .. | ..... | ..... | ..... | ..... | |
| 22 | ..... | *O*..... | 14 18 19 | ..... | ..... | ..... | 3,030 | Wind tremors troublesome on N; $F_E$ occurred while changing paper. |
| | | $eP_E$..... | 14 24 30 | ..... | ..... | ..... | ..... | |
| | | $PR_E$..... | 14 24 50 | ..... | ..... | ..... | ..... | |
| | | S..... | 14 29 04 | 12 | ..... | ..... | ..... | |
| | | $e_E$..... | 14 30 42 | ..... | ..... | ..... | ..... | |
| | | $e_N$..... | 14 30 50 | ..... | ..... | ..... | ..... | |
| | | $L_E$..... | 14 32 04 | ..... | ..... | ..... | ..... | |
| | | $L_N$..... | 14 33 53 | 15 | ..... | ..... | ..... | |
| | | $M_E$..... | 14 40 05 | 16 | *600 | ..... | ..... | |
| | | $M_N$..... | 14 42 13 | 14 | ..... | *1,000 | ..... | |
| | | $F_N$..... | 15 50 .. | 12 | ..... | ..... | ..... | |
| 23 | ..... | $L_E$..... | 7 43 19 | 18 | ..... | ..... | ..... | |
| | | $eL_E$..... | 7 45 14 | 15 | *100 | ..... | ..... | |
| | | $eL_N$..... | 7 46 35 | ..... | ..... | ..... | ..... | |
| | | $M_N$..... | 7 47 22 | 13 | ..... | *200 | ..... | |
| | | $F_E$..... | 7 54 .. | 9 | ..... | ..... | ..... | |
| | | $F_N$..... | 7 56 .. | ..... | ..... | ..... | ..... | |
| 31 | ..... | $S_E$..... | 15 22 12 | 10 | ..... | ..... | ..... | Interpretation based on Honolulu record. |
| | | $e_E$..... | 15 27 23 | 16 | ..... | ..... | ..... | |
| | | $e_N$..... | 15 24 30 | 20 | ..... | ..... | ..... | |
| | | $M_E$..... | 15 27 53 | 13 | *100 | ..... | ..... | |
| | | $M_N$..... | 15 29 03 | 14 | ..... | *100 | ..... | |
| | | $F_E$..... | 16 30 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$..... | 16 19 .. | ..... | ..... | ..... | ..... | |

* Trace amplitude.

TABLE 3—*Late reports (instrumental)*—Continued.

ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| July 12 | ..... | $e_E$ | 5 41 31 | ..... | ..... | ..... | ..... | Local tremors. |
| | | $L_E$ | 5 42 04 | 5 | *100 | ..... | ..... | |
| | | $F_E$ | 5 52 .. | ..... | ..... | ..... | ..... | |
| 12 | ..... | e | 6 13 43 | ..... | ..... | ..... | ..... | Do. |
| | | $L_E$ | 6 14 17 | 5 | *100 | ..... | ..... | |
| | | $F_E$ | 6 22 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 6 16 .. | ..... | ..... | ..... | ..... | |
| 23 | ..... | O | 7 30 40 | ..... | ..... | ..... | 650 | Recorded on the magnetograph. |
| | | $eP_E$ | 7 32 13 | 2 | ..... | ..... | ..... | |
| | | $P_N$ | 7 32 05 | 3 | ..... | ..... | ..... | |
| | | $S_E$ | 7 33 12 | 6 | ..... | ..... | ..... | |
| | | $S_N$ | 7 33 22 | 3 | ..... | ..... | ..... | |
| | | $L_E$ | 7 23 34 | ..... | ..... | ..... | ..... | |
| | | $L_N$ | 7 33 33 | 11 | ..... | ..... | ..... | |
| | | $M_E$ | 7 33 51 | ..... | *3500 | ..... | ..... | |
| | | $M_N$ | 7 33 47 | 10 | ..... | *6900 | ..... | |
| | | $C_N$ | 7 34 45 | 6 | ..... | ..... | ..... | |
| | | $F_E$ | 7 55 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 7 50 .. | ..... | ..... | ..... | ..... | |

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| July 2 | ..... | O | 2 28 44 | ..... | ..... | ..... | 10,500 | |
| | | $P_E$? | 2 41 53 | ..... | ..... | ..... | ..... | |
| | | iS | 2 52 38 | ..... | ..... | ..... | ..... | |
| | | $L_E$ | 3 05 30 | ..... | ..... | ..... | ..... | |
| | | $M_E$ | 3 07 50 | 24 | 14 | ..... | ..... | |
| | | $F_E$ | 3 30 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 3 12 .. | ..... | ..... | ..... | ..... | |
| 4 | ..... | O | 8 30 53 | ..... | ..... | ..... | 3,120 | Slight disturbance is recorded on E at 8:30:49, end lost in next quake. |
| | | $P_E$ | 8 37 04 | ..... | ..... | ..... | ..... | |
| | | $P_N$ | 8 37 01 | ..... | ..... | ..... | ..... | |
| | | $S_N$ | 8 41 53 | 6 | ..... | ..... | ..... | |
| | | $L_E$ | 8 43 56 | ..... | ..... | ..... | ..... | |
| | | $L_N$ | 8 44 17 | 8 | ..... | ..... | ..... | |
| | | $M_E$ | 8 49 59 | 5 | 7 | ..... | ..... | |
| | | $M_N$ | 8 46 45 | 6 | ..... | 14 | ..... | |
| 4 | ..... | $e_E$ | 9 05 56 | ..... | ..... | ..... | ..... | Beginning lost in coda of preceding quake. |
| | | $e_N$ | 9 05 44 | ..... | ..... | ..... | ..... | |
| | | $L_E$ | 9 08 34 | 6 | ..... | ..... | ..... | |
| | | $L_N$ | 9 08 58 | 6 | ..... | ..... | ..... | |
| | | $M_E$ | 9 13 16 | 8 | 8 | ..... | ..... | |
| | | $M_N$ | 9 13 13 | 7 | ..... | 15 | ..... | |
| | | F | 9 23 .. | ..... | ..... | ..... | ..... | |
| 4 | ..... | $e_E$ | 23 19 20 | ..... | ..... | ..... | ..... | |
| | | $e_N$ | 23 19 40 | ..... | ..... | ..... | ..... | |
| | | $F_E$ | 23 30 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 23 35 .. | ..... | ..... | ..... | ..... | |
| 7 | ..... | O | 12 55 18 | ..... | ..... | ..... | 1,940 | |
| | | P | 12 59 24 | ..... | ..... | ..... | ..... | |
| | | S | 13 02 42 | ..... | ..... | ..... | ..... | |
| | | $L_N$ | 13 04 11 | 11 | ..... | ..... | ..... | |
| | | $M_E$ | 13 04 25 | 11 | 12 | ..... | ..... | |
| | | $F_E$ | 13 21 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 13 26 .. | ..... | ..... | ..... | ..... | |
| 10 | ..... | O | 0 43 53 | ..... | ..... | ..... | 6,000 | Interpretation doubtful. |
| | | $P_E$? | 0 53 24 | ..... | ..... | ..... | ..... | |
| | | $P_N$ | 0 54 24 | ..... | ..... | ..... | ..... | |
| | | $S_E$ | 1 01 00 | 21 | ..... | ..... | ..... | |
| | | $S_N$ | 1 01 10 | 21 | ..... | ..... | ..... | |
| | | $L_E1$ | 1 08 55 | ..... | ..... | ..... | ..... | |
| | | $L_E2$ | 1 14 00 | 21 | 8 | ..... | ..... | |
| | | $L_N$ | 1 14 24 | 20 | ..... | 10 | ..... | |
| | | F | 2 20 | ..... | ..... | ..... | ..... | |
| 12 | ..... | O | 3 15 14 | ..... | ..... | ..... | 4,800 | |
| | | iP | 3 23 29 | ..... | ..... | ..... | ..... | |
| | | iS | 3 30 00 | 10 | ..... | ..... | ..... | |
| | | $iL1_E$ | 3 33 19 | 15 | ..... | ..... | ..... | |
| | | $iL2_E$ | 3 34 05 | 12 | ..... | ..... | ..... | |
| | | $L1_N$ | 3 33 50 | 15 | ..... | ..... | ..... | |
| | | $L2_N$ | 3 35 00 | ..... | ..... | ..... | ..... | |
| | | $M_E$ | 3 35 30 | 11 | 48 | ..... | ..... | |
| | | $M_N$ | 3 36 53 | 11 | ..... | 60 | ..... | |
| | | $C_E$ | 3 42 .. | ..... | ..... | ..... | ..... | |
| | | $F_E$ | 5 24 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 5 34 .. | ..... | ..... | ..... | ..... | |
| 12 | ..... | i | 9 28 02 | ..... | ..... | ..... | ..... | |
| | | $iL_E$ | 9 32 05 | 12 | ..... | ..... | ..... | |
| | | $L_N$ | 9 32 10 | 11 | ..... | ..... | ..... | |
| | | $M_E$ | 9 34 00 | 11 | 14 | ..... | ..... | |
| | | $M_N$ | 9 35 30 | 21 | ..... | 22 | ..... | |
| | | $F_E$ | 10 14 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 10 23 .. | ..... | ..... | ..... | ..... | |

*Trace amplitude.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu*—Con.

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| July 13 | ..... | O | 11 13 47 | ..... | ..... | ..... | 7,000 | |
| | | P | 11 24 15 | ..... | ..... | ..... | ..... | |
| | | iS | 11 32 44 | 10 | ..... | ..... | ..... | |
| | | $L1_E$ | 11 41 52 | 26 | ..... | ..... | ..... | |
| | | $L2_E$ | 11 49 20 | ..... | ..... | ..... | ..... | |
| | | $L_N$? | 11 40 04 | ..... | ..... | ..... | ..... | |
| | | $M1_E$ | 11 32 46 | 10 | 30 | ..... | ..... | |
| | | $M2_E$ | 11 43 40 | 20 | 45 | ..... | ..... | |
| | | $M3_E$ | 12 00 00 | 16 | 30 | ..... | ..... | |
| | | $M1_N$ | 11 33 01 | 10 | ..... | 24 | ..... | |
| | | $M2_N$ | 11 47 00 | 12 | ..... | 17 | ..... | |
| | | $F_E$ | 13 18 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 12 50 .. | ..... | ..... | ..... | ..... | |
| 13 | ..... | $e_E$ | 16 17 20 | 13 | ..... | ..... | ..... | |
| | | $F_E$ | 16 23 .. | ..... | ..... | ..... | ..... | |
| 13 | ..... | O | 23 56 42 | ..... | ..... | ..... | 6,820 | Interpretation doubtful. |
| 14 | ..... | $P_E$ ? | 0 07 00 | ..... | ..... | ..... | ..... | |
| | | S | 0 15 20 | ..... | ..... | ..... | ..... | |
| | | $L_E$ | 0 25 40 | ..... | ..... | ..... | ..... | |
| | | $L_N$ | 0 24 40 | 22 | ..... | 12 | ..... | |
| | | $F_E$ | 0 48 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 0 40 .. | ..... | ..... | ..... | ..... | |
| 16 | ..... | O | 13 38 18 | ..... | ..... | ..... | 5,540 | |
| | | $eP_E$ | 13 47 28 | ..... | ..... | ..... | ..... | |
| | | $P_N$ | 13 47 21 | 9 | ..... | ..... | ..... | |
| | | $S_E$ | 13 54 43 | ..... | ..... | ..... | ..... | |
| | | $S_N$ | 13 54 33 | 11 | ..... | ..... | ..... | |
| | | $SR1_E$ | 13 58 25 | 15 | ..... | ..... | ..... | |
| | | $SR1_N$ | 13 58 52 | 11 | ..... | ..... | ..... | |
| | | $L_N$ | 14 00 50 | ..... | ..... | ..... | ..... | |
| | | $M_E$ | 14 03 15 | ..... | ..... | ..... | ..... | |
| | | $M_N$ | 14 01 15 | 11 | ..... | 19 | ..... | |
| | | $F_E$ | 15 01 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 14 55 .. | ..... | ..... | ..... | ..... | |
| 17 | ..... | $e_E$ | 1 23 45 | 8 | ..... | ..... | ..... | |
| | | $e_N$ | 1 23 32 | ..... | ..... | ..... | ..... | |
| | | F | 1 27 .. | ..... | ..... | ..... | ..... | |
| 22 | ..... | O | 14 17 40 | ..... | ..... | ..... | 4,270 | |
| | | $P_E$ | 14 25 20 | ..... | ..... | ..... | ..... | |
| | | $iP_N$ | 14 25 18 | ..... | ..... | ..... | ..... | |
| | | $PR_N$ | 14 26 50 | 13 | ..... | ..... | ..... | |
| | | iS | 14 31 20 | ..... | ..... | ..... | ..... | |
| | | $e_N$ | 14 32 40 | ..... | ..... | ..... | ..... | |
| | | $eL_E$ | 14 35 03 | 11 | ..... | ..... | ..... | |
| | | $L1_N$ | 14 34 32 | 11 | ..... | ..... | ..... | |
| | | $L2_N$ | 14 35 28 | ..... | ..... | ..... | ..... | |
| | | $L3_N$ | 14 36 02 | ..... | ..... | ..... | ..... | |
| | | $M1_E$ | 14 36 35 | 11 | 62 | ..... | ..... | |
| | | $M2_E$ | 14 41 35 | 10 | 62 | ..... | ..... | |
| | | $M_N$ | 14 36 25 | 10 | ..... | 63 | ..... | |
| | | C | 14 45 .. | ..... | ..... | ..... | ..... | |
| | | F | 17 28 .. | ..... | ..... | ..... | ..... | |
| 23 | ..... | SR1 | 7 46 19 | 18 | ..... | ..... | ..... | Interpretation based on Sitka record. |
| | | $eL_E$ | 7 48 15 | 10 | ..... | ..... | ..... | |
| | | $L1_N$ | 7 47 25 | 11 | ..... | ..... | ..... | |
| | | $L2_N$ | 7 49 13 | 10 | ..... | ..... | ..... | |
| | | $M_E$ | 7 50 12 | 10 | 17 | ..... | ..... | |
| | | $M_N$ | 7 49 03 | 10 | ..... | 24 | ..... | |
| | | $C_E$ | 7 57 .. | ..... | ..... | ..... | ..... | |
| | | $C_N$ | 7 54 .. | ..... | ..... | ..... | ..... | |
| | | F | 8 54 .. | ..... | ..... | ..... | ..... | |
| 23 | ..... | e | 9 16 .. | 7 | 3 | 4 | ..... | |
| | | $F_E$ | 9 24 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 9 32 .. | ..... | ..... | ..... | ..... | |
| 26 | ..... | e | 3 36 .. | 11 | 3 | 3 | ..... | |
| | | $F_E$ | 3 38 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 3 41 .. | ..... | ..... | ..... | ..... | |
| 26 | ..... | $e_N$ | 7 44 55 | 5 | ..... | ..... | ..... | E record obscured by overlapping of traces. |
| | | $L_N$ | 7 48 20 | 14 | ..... | ..... | ..... | |
| | | $M_N$ | 7 52 46 | 10 | ..... | 7 | ..... | |
| | | $F_N$ | 8 21 .. | ..... | ..... | ..... | ..... | |
| 26 | ..... | $e_N$ | 10 12 57 | 5 | ..... | ..... | ..... | Do. |
| | | $L_N$ | 10 16 21 | 12 | ..... | ..... | ..... | |
| | | $M_N$ | 10 20 59 | 12 | ..... | 6 | ..... | |
| | | $F_N$ | 11 23 .. | ..... | ..... | ..... | ..... | |
| 31 | ..... | O | 15 07 49 | ..... | ..... | ..... | 4,120 | |
| | | $P_N$ | 15 15 16 | ..... | ..... | ..... | ..... | |
| | | $e_N$ | 15 20 42 | ..... | ..... | ..... | ..... | |
| | | S | 15 21 10 | 9 | ..... | ..... | ..... | |
| | | $L1_E$ | 15 24 30 | 11 | ..... | ..... | ..... | |
| | | $L2_E$ | 15 27 00 | 9 | ..... | ..... | ..... | |
| | | $L1_N$ | 15 24 06 | 14 | ..... | ..... | ..... | |
| | | $L2_N$ | 15 25 20 | 10 | ..... | ..... | ..... | |
| | | $M_E$ | 15 27 45 | 10 | 33 | ..... | ..... | |
| | | $M_N$ | 15 33 20 | 10 | ..... | 22 | ..... | |
| | | $F_E$ | 17 32 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$ | 17 45 .. | ..... | ..... | ..... | ..... | |

TABLE 3.—*Late reports (instrumental)*—Continued.

MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| July 16 | ..... | $e_E$..... | 0 57 31 | ..... | ..... | ..... | ..... | |
| | | $e_N$..... | 0 57 36 | 18 | ..... | *100 | ..... | |
| | | $F_E$..... | 0 23 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$..... | 0 25 .. | ..... | ..... | ..... | ..... | |
| 22 | ..... | *O*..... | 14 17 25 | ..... | ..... | ..... | 7,880 | |
| | | $P_E$..... | 14 28 40 | ..... | ..... | ..... | ..... | |
| | | $eP_N$..... | 14 29 23 | 2 | ..... | ..... | ..... | |
| | | $S_E$..... | 14 37 54 | ..... | ..... | ..... | ..... | |
| | | $S_N$..... | 14 38 16 | 8 | ..... | ..... | ..... | |
| | | $L_E$..... | 14 51 30 | ..... | ..... | ..... | ..... | |
| | | $L1_N$..... | 14 50 19 | ..... | ..... | ..... | ..... | |
| | | $L2_N$..... | 14 52 51 | 25 | ..... | ..... | ..... | |
| | | $M_E$..... | 15 03 28 | 15 | *100 | ..... | ..... | |
| | | $F_E$..... | 15 10 .. | ..... | ..... | ..... | ..... | |
| | | $F_N$..... | 15 30 .. | ..... | ..... | ..... | ..... | |
| 23 | ..... | $e_E$..... | 7 47 11 | 3 | ..... | ..... | ..... | |
| | | $e_N$..... | 7 46 33 | 3 | ..... | ..... | ..... | |
| | | $L_N$..... | 7 47 33 | 16 | ..... | ..... | ..... | |
| | | $M_E$..... | 7 47 55 | 3 | *400 | ..... | ..... | |
| | | $M_N$..... | 7 47 56 | 16 | ..... | *1,000 | ..... | |
| | | $C_E$..... | 7 48 35 | ..... | ..... | ..... | ..... | |
| | | $C_N$..... | 7 48 40 | 9 | ..... | ..... | ..... | |
| | | F..... | 7 58 .. | 4 | ..... | ..... | ..... | |

CANADA. *Dominion Meteorological Service, Toronto.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| July 1 | ..... | e..... | 7 49 03 | ..... | ..... | ..... | ..... | |
| EW | | e..... | 7 50 32 | ..... | ..... | ..... | ..... | |
| | | L..... | 8 54 15 | ..... | ..... | ..... | ..... | |
| | | | to | | | | | |
| | | | 9 12 .. | 15 | ..... | ..... | ..... | E minute vibrations. |
| | | F..... | 9 24 .. | ..... | ..... | ..... | ..... | |
| NS | ..... | L..... | 9 03 14 | ..... | ..... | ..... | ..... | |
| | ..... | ..... | to | | | | | |
| | | | 9 12 .. | 15 | ..... | ..... | ..... | |
| 2 | ..... | L..... | 2 51 00 | ..... | ..... | ..... | ..... | |
| | | L..... | 3 24 10 | 37 | ..... | ..... | ..... | |
| W | | L..... | 3 30 00 | 30 | ..... | ..... | ..... | Small amplitude. |
| | | L..... | 3 48 08 | 11 | ..... | ..... | ..... | |
| | | F..... | 4 46 15 | ..... | ..... | ..... | ..... | |
| | | eL..... | 2 51 12 | ..... | ..... | ..... | ..... | |
| | | L..... | 3 00 30 | 15 | ..... | ..... | ..... | |
| N | ..... | eL..... | 3 30 34 | 30 | ..... | ..... | ..... | |
| | | L..... | 3 36 00 | 25 | ..... | ..... | ..... | |
| | | F..... | 4 24 00 | ..... | ..... | ..... | ..... | |
| 2 | ..... | L..... | 16 56 52 | ..... | ..... | ..... | ..... | Slow wavs not recorded on N. S. component. |
| W | ..... | ..... | to | | | | | |
| | | | 17 10 00 | ..... | ..... | ..... | ..... | |
| 4 | ..... | e..... | 5 44 00 | 8 | ..... | ..... | ..... | |
| | | L..... | 5 47 05 | 13 | ..... | ..... | ..... | |
| W | | F..... | 6 06 00 | ..... | ..... | ..... | ..... | |
| | | P..... | 5 37 41 | 4 | ..... | ..... | ..... | |
| | | i..... | 5 44 07 | ..... | ..... | ..... | ..... | |
| | ..... | ..... | 14 | 8 | ..... | ..... | ..... | |
| N | ..... | L..... | 5 52 08 | 12 | ..... | ..... | ..... | Small amplitude. |
| | | F..... | 6 09 00 | ..... | ..... | ..... | ..... | |
| 4 | ..... | e..... | 8 29 23 | 8 | ..... | ..... | ..... | |
| | | e..... | 8 35 30 | ..... | ..... | ..... | ..... | |
| W | | eL..... | 8 39 00 | 15 | ..... | ..... | ..... | |
| | | F..... | 9 56 00 | ..... | ..... | ..... | ..... | |
| | | e..... | 8 29 20 | ..... | ..... | ..... | ..... | |
| | | i..... | 8 29 23 | ..... | ..... | ..... | ..... | |
| | | e..... | 8 35 09 | ..... | ..... | ..... | ..... | |
| N | ..... | L..... | 8 44 15 | 15 | ..... | ..... | ..... | |
| | | i..... | 8 58 08 | 8 | ..... | ..... | ..... | |
| | | L..... | 9 16 00 | ..... | ..... | ..... | ..... | |
| | | | to | | | | | |
| | ..... | ..... | 9 19 52 | 13 | ..... | ..... | ..... | Small amplitude. |
| | | F..... | 10 01 15 | ..... | ..... | ..... | ..... | |
| 4 | ..... | i..... | 17 08 52 | 11 | ..... | ..... | ..... | |
| W | | i..... | 17 09 49 | ..... | ..... | ..... | ..... | |
| | | F..... | ..... | ..... | ..... | ..... | ..... | |
| | | i..... | 17 08 52 | 11 | ..... | ..... | ..... | |
| N | ..... | i..... | 17 09 51 | ..... | ..... | ..... | ..... | |
| | | F..... | 17 14 00 | ..... | ..... | ..... | ..... | |
| 4 | ..... | L..... | 23 510 0 | ..... | ..... | ..... | ..... | N. S. component |
| W | ..... | eL..... | 23 57 31 | ..... | ..... | ..... | ..... | barely affected. |
| | | | to | | | | | |
| | ..... | ..... | 0 06 22 | 17 | ..... | ..... | ..... | |
| | | F..... | 0 25 30 | ..... | ..... | ..... | ..... | |
| 5 | ..... | L..... | 16 06 00 | ..... | ..... | ..... | ..... | Doubtful as to being seismic. |
| W | ..... | ..... | to | | | | | |
| | | | 16 26 00 | ..... | ..... | ..... | ..... | |

* Trace amplitude.

CANADA. *Dominion Meteorological Service, Toronto*—Continued.

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| July 6 | ..... | L..... | 6 04 53 | ..... | ..... | ..... | ..... | Slow waves. Nothing on NS component. |
| W | ..... | F..... | 6 16 00 | ..... | ..... | ..... | ..... | |
| 7 | ..... | e..... | 6 25 34 | ..... | ..... | ..... | ..... | Minute vibrations 6:30; 41 to 6:34:00 |
| | | e..... | 6 28 41 | ..... | ..... | ..... | ..... | |
| W | ..... | i..... | 6 29 33 | ..... | ..... | ..... | ..... | |
| | | L..... | 6 38 30 | ..... | ..... | ..... | ..... | |
| | | F..... | 7 05 00 | ..... | ..... | ..... | ..... | |
| | | e..... | 6 28 26 | ..... | ..... | ..... | ..... | Small amp. |
| N | ..... | i..... | 6 29 20 | ..... | ..... | ..... | ..... | Sharp vibs. 6:30 to 6:34 with a period of 8 secs. |
| | ..... | F..... | 6 54 00 | ..... | ..... | ..... | ..... | |
| 7 | ..... | e..... | 13 38 15 | ..... | ..... | ..... | ..... | Slow waves up to 13h. 48m. when paper was taken off. |
| W | ..... | ..... | ..... | ..... | ..... | ..... | ..... | |
| N | ..... | e..... | 13 38 27 | ..... | ..... | ..... | ..... | |
| 10 | ..... | e..... | 0 30 45 | ..... | ..... | ..... | ..... | Slow waves. Nothing on NS component. |
| | | F..... | 0 36 24 | ..... | ..... | ..... | ..... | |
| 10 | ..... | P..... | Not recorded. | ..... | ..... | ..... | ..... | |
| | | S..... | 0 50 07 | 11 | ..... | ..... | ..... | |
| | | L..... | 1 02 45 | ..... | ..... | ..... | ..... | |
| W | ..... | L..... | 1 24 45 | 19 | ..... | ..... | ..... | Small amp. |
| | | F..... | 3 06 15 | ..... | ..... | ..... | ..... | |
| | | P..... | 0 40 42 | 6 | ..... | ..... | ..... | |
| | | S..... | 0 50 07 | 12 | ..... | ..... | ..... | |
| | | L..... | 0 59 15 | ..... | ..... | ..... | 8,110 | Km. Small amp. |
| N | ..... | L..... | 1 02 30 | ..... | ..... | ..... | ..... | |
| | | L..... | 1 20 41 | 15 | ..... | ..... | ..... | |
| | | F..... | ?2 44 00 | ..... | ..... | ..... | ..... | |
| 10 | ..... | e..... | 5 48 40 | ..... | ..... | ..... | ..... | |
| W | ..... | F..... | 5 48 50 | ..... | ..... | ..... | ..... | Very small, may not be seismic. |
| | | e..... | 5 48 30 | ..... | ..... | ..... | ..... | |
| N | ..... | F..... | 5 48 45 | ..... | ..... | ..... | ..... | |
| 12 | ..... | e..... | 3 34 23 | 5 | ..... | ..... | ..... | |
| | | i..... | 3 40 45 | ..... | ..... | ..... | ..... | |
| W | ..... | S..... | 3 43 44 | 9 | ..... | ..... | ..... | |
| | | e..... | 3 50 00 | 15 | ..... | ..... | ..... | |
| | | L..... | 3 54 22 | ..... | ..... | ..... | ..... | |
| | | L..... | 4 05 37 | ..... | ..... | ..... | ..... | |
| | | eL..... | 4 06 49 | 38 | ..... | 28 | ..... | |
| | | L to F. | 4 11 00 | ..... | ..... | ..... | ..... | |
| | | | 4 15 30 | 22 | ..... | ..... | ..... | |
| | | | 6 12 00 | ..... | ..... | ..... | ..... | |
| | | e..... | 3 42 02 | ..... | ..... | ..... | ..... | |
| | | e..... | 3 49 49 | ..... | ..... | ..... | ..... | |
| N | ..... | L..... | 4 02 26 | 38 | ..... | ..... | ..... | |
| | | L..... | 4 10 38 | 23 | 19 | ..... | ..... | |
| | | F..... | 6 12 00 | ..... | ..... | ..... | ..... | |
| 12 | ..... | i..... | 9 42 00 | ..... | ..... | ..... | ..... | |
| | | e..... | 9 48 04 | ..... | ..... | ..... | ..... | Uniform waves 10h. 09m. 37s. to 10h. 14m. 00s. |
| | | L..... | 10 06 53 | ..... | ..... | ..... | ..... | |
| W | ..... | L..... | 10 09 37 | ..... | ..... | ..... | ..... | |
| | | | to | | | | | |
| | | | 10 15 30 | ..... | ..... | ..... | ..... | Small amp. |
| | | F..... | ?11 14 00 | ..... | ..... | ..... | ..... | Slight undulatory movements on NS component. |
| 13 | ..... | eP..... | 11 27 28 | ..... | ..... | ..... | ..... | |
| | | PR1.. | 11 31 33 | ..... | ..... | ..... | ..... | |
| | | S..... | 11 38 00 | 8 | ..... | ..... | ..... | |
| N | ..... | i..... | 11 38 06 | ..... | ..... | ..... | ..... | |
| | | L..... | ?11 58 00 | ..... | ..... | ..... | ..... | |
| | | L..... | 12 00 38 | ..... | ..... | ..... | ..... | |
| | | L..... | 12 10 00 | 23 | ..... | ..... | ..... | |
| | | | to | | | | | |
| | | | 12 14 45 | | | | | |
| | | L..... | 12 16 45 | ..... | ..... | ..... | ..... | |
| | | | to | | | | | |
| | | | 12 21 15 | | | | | |
| | | M1..... | 12 18 00 | 18 | 55 | ..... | 9,440 | Well-defined record. |
| | | M2..... | 12 18 17 | ..... | ..... | ..... | ..... | |
| | | M3..... | 12 18 34 | ..... | ..... | ..... | ..... | Uniform waves 12h. 16m. 45s. to 12h. 19m. 00s. |
| | | F..... | 14 02 00 | ..... | ..... | ..... | ..... | |
| | | P..... | ?11 27 34 | ..... | ..... | ..... | ..... | |
| | | e..... | 11 30 17 | ..... | ..... | ..... | ..... | |
| W | ..... | PR1.. | 11 31 35 | ..... | ..... | ..... | ..... | |
| | | S..... | 11 38 01 | 8 | ..... | ..... | ..... | P not defined, preceded by undulatory movements. |
| | | L..... | 11 58 00 | 15 | ..... | ..... | ..... | |
| | | L..... | 12 02 08 | 43 | ..... | ..... | ..... | |
| | | L..... | 12 04 30 | 34 | ..... | ..... | ..... | |
| | | | to | | | | | |
| | | | 12 06 15 | | | | | |
| | | M1..... | 12 09 40 | 22 | ..... | ..... | ..... | |
| | | M2..... | 12 10 55 | ..... | ..... | ..... | ..... | |
| | | M3..... | 12 12 08 | 22 | ..... | ..... | ..... | |
| | | M4..... | 12 13 26 | 22 | ..... | ..... | ..... | |
| | | M5..... | 12 13 47 | 22 | ..... | 45 | 9,340 | |
| | | F..... | ..... | ..... | ..... | ..... | ..... | |

TABLE 3.—*Late reports (instrumental)*—Continued.

CANADA. *Dominion Meteorological Service, Toronto*—Continued.

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| July 14 | ..... | e..... | 23 03 30 | ..... | ..... | ..... | ..... | |
| W | ..... | L..... | 0 44 45 | ..... | ..... | ..... | ..... | Slow waves, but nothing defined. |
| | | | to | | | | | |
| | | | 1 12 00 | | | | | |
| | | F..... | ?1 56 00 | ..... | ..... | ..... | ..... | |
| | | e..... | 0 45 30 | ..... | ..... | ..... | ..... | |
| N | ..... | L..... | 0 45 52 | ..... | ..... | ..... | ..... | No marked features. |
| | | | to | | | | | |
| | | | 1 05 00 | | | | | |
| | | F..... | 1 37 00 | ..... | ..... | ..... | ..... | |
| 15 | ..... | e..... | 3 58 37 | ..... | ..... | ..... | ..... | |
| W | ..... | F..... | 4 00 00 | ..... | ..... | ..... | ..... | Undulatory. |
| 16 | ..... | e..... | 13 58 22 | ..... | ..... | ..... | ..... | |
| | | i..... | 14 04 07 | ..... | ..... | ..... | ..... | Marked uniform |
| | | L or S. | 14 08 00 | ..... | ..... | ..... | ..... | waves from 14h. |
| W | ..... | L..... | 14 14 53 | 11 | ..... | ..... | ..... | 38m. to 15h. 04 |
| | | eL..... | 14 33 30 | 37 | ..... | ..... | ..... | m., gradually de- |
| | | M..... | ?..... | ..... | ..... | 20 | ..... | creasing, 19 sec- |
| | | F..... | 16 28 .. | ..... | ..... | ..... | ..... | onds period. |
| | | e..... | 14 06 20 | ..... | ..... | ..... | ..... | |
| | | S?..... | 14 08 10 | ..... | ..... | ..... | ..... | |
| | | i or S.. | 14 15 02 | ..... | ..... | ..... | ..... | |
| | | L..... | 14 30 22 | 15 to 19 | ..... | ..... | ..... | |
| N | ..... | L..... | 14 46 00 | ..... | ..... | ..... | ..... | |
| | | | to | | | | | |
| | | | 14 50 38 | ..... | 9 | ..... | ..... | Uniform waves of |
| | | F..... | 15 40 00 | ..... | ..... | ..... | ..... | small amplitude. |
| 17 | ..... | i..... | 1 16 41 | ..... | ..... | ..... | ..... | |
| W | ..... | i..... | 1 20 08 | ..... | ..... | ..... | ..... | Minute ripples at |
| | | L?..... | 1 23 05 | ..... | ..... | ..... | ..... | 1h. 16m. 41s. |
| | | F..... | 2 08 00 | ..... | ..... | ..... | ..... | Very irregular |
| | | e..... | 1 19 02 | ..... | ..... | ..... | ..... | waves, small |
| | | i..... | 1 25 30 | ..... | ..... | ..... | ..... | amp. |
| N | ..... | i..... | 1 28 16 | ..... | ..... | ..... | ..... | |
| | | F..... | 1 58 00 | ..... | ..... | ..... | ..... | |
| 18 | ..... | P..... | 1 13 06 | ..... | ..... | ..... | ..... | |
| | | PR..... | 1 14 28 | ..... | ..... | ..... | ..... | 3980. Uniform |
| | | S..... | 1 18 52 | ..... | ..... | ..... | ..... | waves from 1h. |
| | | L..... | 1 22 19 | ..... | ..... | ..... | ..... | 24m. 38s. small |
| W | ..... | eL..... | 1 24 38 | 25 to 30 | ..... | ..... | ..... | amp. |
| | | | to | | | | | |
| | | | 1 31 52 | | | | | |
| | | F..... | 2 02 00 | ..... | ..... | ..... | ..... | |
| | | PR1.. | 1 14 28 | ..... | ..... | ..... | ..... | |
| | | eS..... | 1 18 53 | ..... | ..... | ..... | ..... | P not recorded. |
| N | ..... | eL..... | 1 24 25 | ..... | ..... | ..... | ..... | |
| | | eL..... | 1 25 12 | ..... | ..... | ..... | ..... | |
| | | F..... | 1 40 00 | ..... | ..... | ..... | ..... | |
| 18 | ..... | P..... | 6 09 22 | ..... | ..... | ..... | ..... | |
| | | PR1.. | 6 10 45 | ..... | ..... | ..... | 3,980 | Small amp. |
| | | Si..... | 6 15 08 | ..... | ..... | ..... | ..... | |
| W | ..... | L..... | 6 20 00 | 23 to 30 | ..... | ..... | ..... | |
| | | | to | | | | | |
| | | | 6 28 53 | | | | | |
| | | F..... | 7 04 00 | ..... | ..... | ..... | ..... | |
| 18 | ..... | P..... | 6 09 19 | ..... | ..... | ..... | ..... | |
| | | PR1.. | 6 10 45 | ..... | ..... | ..... | ..... | |
| | | iS..... | 6 15 10 | 8 | ..... | ..... | ..... | |
| N | ..... | L..... | 6 18 37 | ..... | ..... | ..... | ..... | |
| | | eL..... | 6 20 30 | ..... | ..... | ..... | ..... | |
| | | L..... | 6 22 00 | 15 | ..... | ..... | ..... | |
| | | F..... | 6 44 00 | ..... | ..... | ..... | ..... | |
| 20 | ..... | i..... | 5 07 38 | ..... | ..... | ..... | ..... | Small amp. |
| W | ..... | eL..... | 5 17 24 | ..... | ..... | ..... | ..... | Very gradual |
| | | F..... | 5 46 00 | ..... | ..... | ..... | ..... | movement 5h. |
| | | | | | | | | 17m. 24s. |
| | | e..... | 5 07 45 | ..... | ..... | ..... | ..... | |
| N | ..... | L..... | 5 17 30 | ..... | ..... | ..... | ..... | |
| | | L..... | 5 41 00 | ..... | ..... | ..... | ..... | |
| 20 | ..... | L..... | 15 24 00 | ..... | ..... | ..... | ..... | Small amp. |
| W | ..... | eL..... | 15 36 36 | 30 | ..... | ..... | ..... | |
| | | L..... | 15 42 45 | ..... | ..... | ..... | ..... | |
| | | L..... | 15 45 45 | ..... | ..... | ..... | ..... | Changing paper. |
| | | e..... | 15 23 38 | ..... | ..... | ..... | ..... | |
| | | eL..... | 15 32 30 | 37 | ..... | ..... | ..... | |
| N | ..... | L..... | 15 34 15 | 18 | ..... | ..... | ..... | |
| | | F..... | ..... | ..... | ..... | ..... | ..... | Changing paper. |
| 21 | ..... | L..... | 7 02 30 | ..... | ..... | ..... | ..... | |
| W | ..... | eL..... | 7 18 15 | ..... | ..... | ..... | ..... | Slow waves. |
| | | F..... | 7 36 00 | ..... | ..... | ..... | ..... | Nothing on NS component. |
| 21 | ..... | L..... | 8 01 32 | ..... | ..... | ..... | ..... | May not be seismic. |
| W | ..... | F..... | 8 38 00 | ..... | ..... | ..... | ..... | |
| 22 | ..... | P..... | 14 28 47 | ..... | ..... | ..... | ..... | |
| | | e..... | 14 37 30 | ..... | ..... | ..... | ..... | |
| W | ..... | iS..... | 14 37 34 | 10 | ..... | ..... | ..... | |
| | | SR..... | 14 45 00 | ..... | ..... | ..... | ..... | |
| | | i..... | 14 45 08 | ..... | ..... | ..... | ..... | 7360. Well-defined |
| | | L..... | 14 48 47 | ..... | ..... | ..... | ..... | waves from 14h. |
| | | iL..... | 14 49 52 | ..... | ..... | ..... | ..... | 50m. 48s. to 15h. |
| | | L..... | 14 50 50 | 30 | ..... | ..... | ..... | 24m. |
| | | M..... | 14 59 17 | 17 | ..... | 40 | ..... | |
| | | F..... | ?18 18 00 | ..... | ..... | ..... | ..... | |

CANADA. *Dominion Meteorological Service, Toronto*—Continued.

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| July 22 | ..... | eP..... | 14 28 41 | ..... | ..... | ..... | ..... | |
| | | iS..... | 14 37 36 | ..... | ..... | ..... | ..... | |
| | | SRI.. | 14 45 14 | ..... | ..... | ..... | ..... | |
| N | ..... | L..... | 14 48 46 | ..... | ..... | ..... | 7,510 | |
| | | L..... | 14 50 45 | ..... | ..... | ..... | ..... | |
| | | M..... | 15 02 07 | 15 | 25 | ..... | ..... | |
| | | F..... | 17 58 00 | ..... | ..... | ..... | ..... | |
| 23 | ..... | e..... | 7 40 08 | ..... | ..... | ..... | ..... | |
| | | e..... | 7 40 50 | ..... | ..... | ..... | ..... | Minute vibrations |
| | | S..... | 7 41 48 | ..... | ..... | ..... | ..... | at beginning. |
| W | ..... | i..... | 7 46 28 | ..... | ..... | ..... | ..... | |
| | | i..... | 7 46 58 | ?? | ..... | ..... | ..... | |
| | | L..... | 7 47 10 | 13 | ..... | ..... | ..... | Well defined, 7h |
| | | | to | | | | | 49m to 7h. 56 m. |
| | | | 7 56 52 | 8 to 11 | ..... | 40 | ..... | |
| | | M..... | 7 49 36 | 7 | ..... | ..... | ..... | |
| | | F..... | 9 30 00 | ..... | ..... | ..... | ..... | |
| | | S..... | 7 41 48 | ..... | ..... | ..... | ..... | P not discernable. |
| | | i..... | 7 46 29 | ..... | ..... | ..... | ..... | |
| | | L..... | 7 46 45 | ..... | ..... | ..... | ..... | |
| N | ..... | L..... | 7 47 00 | 5 to 15 | ..... | ..... | ..... | |
| | | | to | | | | | |
| | | | 7 51 00 | | | | | |
| | | M..... | 7 47 12 | ..... | 173 | ..... | ..... | Well defined. |
| | | F..... | 9 29 00 | ..... | ..... | ..... | ..... | |
| 25 | ..... | e..... | 2 04 25 | ..... | ..... | ..... | ..... | |
| | | e..... | 2 16 00 | ..... | ..... | ..... | ..... | Undulatory, may |
| W | ..... | F..... | 2 44 45 | ..... | ..... | ..... | ..... | not be seismic. |
| | | | | | | | | Nothing on NS component. |
| 26 | ..... | e..... | 3 20 00 | ..... | ..... | ..... | ..... | |
| | | L..... | 3 26 23 | 15 to 22 | ..... | ..... | ..... | |
| | | | to | | | | | |
| W | ..... | | 3 38 00 | ..... | ..... | ..... | ..... | Small amp. |
| | | F..... | 3 58 00 | ..... | ..... | ..... | ..... | NS component very slightly affected. |
| 26 | ..... | e..... | 10 10 30 | ..... | ..... | ..... | ..... | |
| | | e..... | 10 32 38 | ..... | ..... | ..... | ..... | Series of concord- |
| | | eL..... | 10 52 15 | 15 | ..... | ..... | ..... | ent waves of |
| | | | to | | | | | small amp. |
| W | ..... | | 11 07 00 | ..... | ..... | ..... | ..... | |
| | | F..... | ?11 58 00 | ..... | ..... | ..... | ..... | |
| | | | | | | | | NS component barely affected. |
| 27 | ..... | e..... | 2 12 00 | ..... | ..... | ..... | ..... | |
| | | L..... | 2 14 45 | ..... | ..... | ..... | ..... | |
| | | L..... | 2 22 53 | ..... | ..... | ..... | ..... | |
| W | ..... | L..... | 2 28 45 | ..... | ..... | ..... | ..... | Undulatory. |
| | | F..... | 3 42 00 | ..... | ..... | ..... | ..... | |
| | | e..... | 2 16 23 | ..... | ..... | ..... | ..... | |
| N | ..... | e..... | 2 32 33 | ..... | ..... | ..... | ..... | |
| 28 | ..... | e..... | 18 36 28 | ..... | ..... | ..... | ..... | May not be seismic. |
| | | | to | | | | | |
| | | | 18 28 00 | ..... | ..... | ..... | ..... | |
| 31 | ..... | i..... | 5 51 26 | ..... | ..... | ..... | ..... | |
| | | i..... | 5 53 39 | ..... | ..... | ..... | ..... | |
| | | i..... | 5 54 32 | ..... | ..... | ..... | ..... | |
| W | ..... | i..... | 5 54 40 | ..... | ..... | ..... | ..... | Small amp. |
| | | e..... | 5 58 37 | ..... | ..... | ..... | ..... | |
| | | e..... | 5 59 15 | ..... | ..... | ..... | ..... | |
| | | L?..... | ?6 01 17 | ..... | ..... | ..... | ..... | |
| | | F..... | 6 24 00 | ..... | ..... | ..... | ..... | |
| | | i..... | 5 53 40 | ..... | ..... | ..... | ..... | |
| | | e..... | 5 54 16 | ..... | ..... | ..... | ..... | |
| N | ..... | i..... | 5 54 36 | ..... | ..... | ..... | ..... | L waves difficult |
| | | i..... | 5 55 33 | ..... | ..... | ..... | ..... | to interpret. |
| | | L..... | ?5 58 44 | ..... | ..... | ..... | ..... | |
| | | L..... | 6 03 15 | ..... | ..... | ..... | ..... | |
| | | F..... | 6 23 00 | ..... | ..... | ..... | ..... | |
| 31 | ..... | L..... | 16 04 00 | ..... | ..... | ..... | ..... | Small uniform L |
| W | ..... | F..... | ..... | ..... | ..... | ..... | ..... | waves going on when paper was put on at 15h. 44m. to 16h. 03m. 38s. Period 10 to 15s. |
| N | ..... | i..... | 16 04 44 | ..... | ..... | ..... | ..... | |
| | | L..... | 16 08 24 | ..... | ..... | ..... | ..... | |
| | | F..... | ..... | ..... | ..... | ..... | ..... | |

CANADA. *Dominion Meteorological Service, Victoria.*

| 1923. | | | H. m. s. | Sec. | μ | μ | Km. | |
|---|---|---|---|---|---|---|---|---|
| July 1 | ..... | L..... | 8 44 24 | 20 | ..... | ..... | ..... | |
| E | ..... | M..... | 8 52 34 | 15 | ..... | 1 | ..... | |
| | | F..... | 9 26 36 | ..... | ..... | ..... | ..... | |
| | | L..... | 8 44 06 | 20 | ..... | ..... | ..... | |
| N | ..... | F..... | 9 26 34 | ..... | ..... | ..... | ..... | |

TABLE 3.—*Late reports (instrumental)*—Continued.

CANADA. *Dominion Meteorological Service, Victoria*—Continued.

| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* |
|---|---|---|---|---|---|---|---|
| July 2 | ..... | P..... | 2 44 51 | 8 | ..... | ..... | ..... |
| | ..... | S..... | 2 55 16 | 10 | ..... | ..... | ..... |
| E | ..... | L..... | 3 15 50 | 20 | ..... | ..... | ..... |
| | ..... | M..... | 3 27 52 | 15 | ..... | 4 | 9,290 |
| | ..... | F..... | 5 02 40 | ..... | ..... | ..... | ..... |
| | ..... | P..... | 2 45 01 | 10 | ..... | ..... | ..... |
| | ..... | S..... | 2 55 40 | 10 | ..... | ..... | ..... |
| N | ..... | L..... | 3 19 45 | 12 | ..... | ..... | ..... |
| | ..... | M..... | 3 37 05 | 12 | 3 | ..... | ..... |
| | ..... | F..... | 5 01 45 | ..... | ..... | ..... | 9,580 |
| 4 | ..... | P..... | 5 40 18 | 5 | ..... | ..... | ..... |
| E | ..... | M..... | 5 48 24 | 10 | ..... | 2 | ..... |
| | ..... | F..... | 6 23 48 | ..... | ..... | ..... | ..... |
| | ..... | P..... | 5 40 07 | 5 | ..... | ..... | ..... |
| | ..... | L..... | 5 48 08 | 10 | ..... | ..... | ..... |
| N | ..... | M..... | 5 48 43 | 10 | 1 | ..... | ..... |
| | ..... | F..... | 6 28 46 | ..... | ..... | ..... | ..... |
| 4 | ..... | P..... | 8 25 41 | 8 | ..... | ..... | ..... |
| | ..... | S..... | 8 30 07 | 10 | ..... | ..... | ..... |
| E | ..... | L..... | 8 36 46 | 20 | ..... | ..... | ..... |
| | ..... | M..... | 8 43 20 | 18 | ..... | 9 | 2,770 |
| | ..... | F..... | 9 51 40 | ..... | ..... | ..... | ..... |
| | ..... | P..... | 8 25 38 | 5 | ..... | ..... | ..... |
| | ..... | S..... | 8 30 00 | 8 | ..... | ..... | ..... |
| N | ..... | L..... | 8 36 50 | 20 | ..... | ..... | ..... |
| | ..... | M..... | 8 42 53 | 18 | 5 | ..... | 2,720 |
| | ..... | F..... | 9 40 08 | ..... | ..... | ..... | ..... |
| 4 | ..... | L..... | 17 12 40 | 8 | ..... | ..... | ..... |
| E | ..... | M..... | 17 12 43 | 8 | ..... | 3 | ..... |
| | ..... | F..... | 17 22 47 | ..... | ..... | ..... | ..... |
| | ..... | L..... | 17 12 44 | 10 | ..... | ..... | ..... |
| N | ..... | M..... | 17 13 43 | 8 | 2 | ..... | ..... |
| | ..... | F..... | 17 25 08 | ..... | ..... | ..... | ..... |
| 4 E | ..... | L..... | 23 23 44 | 10 | ..... | ..... | ..... |
| N | ..... | L..... | 23 23 46 | 10 | ..... | ..... | ..... |
| 7 | ..... | P..... | 6 13 05 | 5 | ..... | ..... | ..... |
| | ..... | S..... | 6 15 30 | 6 | ..... | ..... | ..... |
| E | ..... | L..... | 6 17 45 | 8 | ..... | ..... | ..... |
| | ..... | M..... | 6 18 48 | 10 | ..... | 5 | 1,380 |
| | ..... | F..... | 6 56 10 | ..... | ..... | ..... | ..... |
| | ..... | P..... | 6 13 05 | 5 | ..... | ..... | ..... |
| | ..... | S..... | 6 15 40 | 6 | ..... | ..... | ..... |
| N | ..... | L..... | 6 17 42 | 8 | ..... | ..... | ..... |
| | ..... | M..... | 6 19 14 | 8 | 3 | ..... | 1,480 |
| | ..... | F..... | 6 57 10 | ..... | ..... | ..... | ..... |
| 7 | ..... | L..... | 13 23 42 | 10 | ..... | ..... | ..... |
| E | ..... | M..... | ?13 35 19 | 15 | ..... | 1 | ..... |
| | ..... | F..... | 13 46 40 | ..... | ..... | ..... | ..... |
| | ..... | L..... | 13 20 27 | 10 | ..... | ..... | ..... |
| N | ..... | M..... | ?13 29 47 | 18 | 1 | ..... | ..... |
| | ..... | F..... | 13 47 42 | ..... | ..... | ..... | ..... |
| 10 | ..... | P..... | 0 42 28 | 10 | ..... | ..... | ..... |
| | ..... | S..... | 0 53 06 | 10 | ..... | ..... | ..... |
| E | ..... | L..... | 1 12 56 | 16 | ..... | ..... | ..... |
| | ..... | M..... | 1 25 48 | 13 | ..... | 4 | 10,920 |
| | ..... | F..... | 3 15 33 | ..... | ..... | ..... | ..... |
| | ..... | P..... | 0 42 21 | 6 | ..... | ..... | ..... |
| | ..... | S..... | 0 53 04 | 10 | ..... | ..... | ..... |
| N | ..... | L..... | 1 12 46 | 18 | ..... | ..... | ..... |
| | ..... | M..... | 1 34 34 | 14 | 3 | ..... | 11,040 |
| | ..... | F..... | 2 56 28 | ..... | ..... | ..... | ..... |
| 10 | ..... | L..... | 16 53 20 | 12 | ..... | ..... | ..... |
| E | ..... | M..... | 16 55 14 | 8 | ..... | 1 | ..... |
| | ..... | F..... | 17 10 42 | ..... | ..... | ..... | ..... |
| | ..... | L..... | 16 53 17 | 17 | ..... | ..... | ..... |
| N | ..... | M..... | 16 55 10 | 10 | 2 | ..... | ..... |
| | ..... | F..... | 17 10 38 | ..... | ..... | ..... | ..... |
| 12 | ..... | P..... | 3 27 55 | 5 | ..... | ..... | ..... |
| | ..... | S..... | 3 38 08 | 10 | ..... | ..... | ..... |
| E | ..... | L..... | 3 52 40 | 30 | ..... | ..... | ..... |
| | ..... | M..... | 4 01 50 | 20 | ..... | 26 | 9,050 |
| | ..... | F..... | 6 40 00 | ..... | ..... | ..... | ..... |
| | ..... | P..... | 3 27 58 | 5 | ..... | ..... | ..... |
| | ..... | S..... | 3 38 08 | 10 | ..... | ..... | ..... |
| N | ..... | L..... | 3 52 40 | 30 | ..... | ..... | ..... |
| | ..... | M..... | 3 58 50 | 15 | 11 | ..... | 9,000 |
| | ..... | F..... | 6 40 00 | ..... | ..... | ..... | ..... |
| 12 | ..... | P..... | 9 26 50 | 5 | ..... | ..... | ..... |
| | ..... | S..... | 9 36 35 | 10 | ..... | ..... | ..... |
| E | ..... | L..... | 9 49 56 | 20 | ..... | ..... | ..... |
| | ..... | M..... | 10 00 08 | 18 | ..... | 5 | 8,490 |
| | ..... | F..... | 10 51 46 | ..... | ..... | ..... | ..... |
| | ..... | P..... | 9 26 26 | 5 | ..... | ..... | ..... |
| | ..... | S..... | 9 36 12 | 8 | ..... | ..... | ..... |
| N | ..... | L..... | 9 50 38 | 20 | ..... | ..... | ..... |
| | ..... | M..... | 9 56 35 | 20 | 4 | ..... | 8,520 |
| | ..... | F..... | 10 50 30 | ..... | ..... | ..... | ..... |

CANADA. *Dominion Meteorological Service, Victoria*—Continued.

| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
|---|---|---|---|---|---|---|---|---|
| July 13 | ..... | P..... | 11 25 20 | 8 | ..... | ..... | ..... | |
| | ..... | S..... | 11 35 15 | 10 | ..... | ..... | ..... | |
| E | ..... | L..... | 11 54 00 | 22 | ..... | ..... | ..... | |
| | ..... | M..... | 12 02 20 | 16 | ..... | 8 | 8,690 | |
| | ..... | F..... | 14 20 00 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 11 25 20 | 8 | ..... | ..... | ..... | |
| | ..... | S..... | 11 35 16 | 10 | ..... | ..... | ..... | |
| | ..... | L..... | 11 54 00 | 22 | ..... | ..... | ..... | |
| N | ..... | M..... | (?) | ..... | (?) | ..... | 8,690 | |
| | ..... | F..... | ?14 20 00 | ..... | ..... | ..... | ..... | |
| 14 | ..... | P..... | 0 08 08 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 0 17 58 | 8 | ..... | ..... | ..... | |
| E | ..... | L..... | 0 35 05 | 20 | ..... | ..... | ..... | |
| | ..... | M..... | 0 44 02 | 20 | ..... | 3 | 8,590 | |
| | ..... | F..... | 1 44 50 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 0 08 08 | 5 | ..... | ..... | ..... | |
| N | ..... | S..... | 0 17 58 | 8 | ..... | ..... | ..... | |
| | ..... | F..... | 1 45 00 | ..... | ..... | ..... | 8,590 | |
| 15 | ..... | P..... | 1 32 10 | 4 | ..... | ..... | ..... | |
| E | ..... | M..... | 1 32 18 | 4 | ..... | 2 | 70 | |
| | ..... | F..... | 1 33 58 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 1 32 08 | 4 | ..... | ..... | ..... | |
| N | ..... | M..... | 1 32 15 | 4 | 2 | ..... | 60 | |
| | ..... | F..... | 1 33 51 | ..... | ..... | ..... | ..... | |
| 15 | ..... | P..... | 4 24 06 | ..... | ..... | ..... | ..... | |
| E | ..... | M..... | 4 24 20 | 4 | ..... | 1 | 130 | |
| | ..... | F..... | 4 26 00 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 4 24 15 | 4 | ..... | ..... | ..... | |
| N | ..... | M..... | 4 24 27 | 7 | 2 | ..... | 110 | |
| | ..... | F..... | 4 26 00 | ..... | ..... | ..... | ..... | |
| 16 | ..... | P..... | 13 51 20 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 14 02 00 | 10 | ..... | ..... | ..... | |
| E | ..... | L..... | 14 19 15 | 20 | ..... | ..... | ..... | |
| | ..... | M..... | 14 35 20 | 18 | ..... | 9 | 9,600 | |
| | ..... | F..... | 16 58 00 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 13 51 20 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 14 01 58 | 10 | ..... | ..... | ..... | |
| N | ..... | M..... | 14 35 18 | 15 | 3 | ..... | 9,560 | |
| | ..... | F..... | 16 25 00 | ..... | ..... | ..... | ..... | |
| 17 | ..... | P..... | 1 06 38 | 8 | ..... | ..... | ..... | |
| | ..... | S..... | 1 10 25 | 8 | ..... | ..... | ..... | |
| E | ..... | L..... | 1 14 00 | 8 | ..... | ..... | ..... | |
| | ..... | M..... | 1 14 22 | 10 | ..... | 6 | 2,280 | |
| | ..... | F..... | 2 09 30 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 1 06 40 | 6 | ..... | ..... | ..... | |
| | ..... | S..... | 1 10 30 | 8 | ..... | ..... | ..... | |
| | ..... | L..... | 1 14 07 | 8 | ..... | ..... | ..... | |
| N | ..... | M..... | 1 15 52 | 8 | 3 | ..... | 2,320 | |
| | ..... | F..... | 2 06 20 | ..... | ..... | ..... | ..... | |
| 18 | ..... | L..... | 1 36 55 | 10 | ..... | ..... | ..... | |
| E | ..... | M..... | 1 42 10 | 15 | ..... | 2 | ..... | |
| | ..... | F..... | 2 03 00 | ..... | ..... | ..... | ..... | |
| | ..... | L..... | 1 38 20 | 15 | ..... | ..... | ..... | |
| N | ..... | F..... | 1 58 00 | ..... | ..... | ..... | ..... | |
| 18 | ..... | M..... | 6 34 28 | 10 | ..... | 2 | ..... | |
| E | ..... | F..... | 7 08 25 | ..... | ..... | ..... | ..... | |
| | ..... | L..... | 6 16 22 | 8 | ..... | ..... | ..... | |
| N | ..... | M..... | 6 36 49 | 20 | 4 | ..... | ..... | |
| | ..... | F..... | 7 08 58 | ..... | ..... | ..... | ..... | |
| 20 | ..... | P..... | 15 28 55 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 15 36 11 | 10 | ..... | ..... | ..... | |
| E | ..... | L..... | 15 44 00 | 25 | ..... | ..... | ..... | |
| | ..... | M..... | 15 54 50 | 25 | ..... | 6 | 5,620 | |
| | ..... | F..... | (?) | ..... | ..... | ..... | ..... | |
| | ..... | L..... | 15 44 00 | 30 | ..... | ..... | ..... | |
| N | ..... | M..... | 15 50 08 | 25 | 5 | ..... | ..... | |
| | ..... | F..... | (?) | ..... | ..... | ..... | ..... | |
| 22 | ..... | P..... | 14 25 33 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 14 31 33 | 8 | ..... | ..... | ..... | |
| E | ..... | L..... | 14 41 49 | 18 | ..... | ..... | ..... | |
| | ..... | M..... | 14 47 13 | 15 | ..... | 24 | 4,220 | |
| | ..... | F..... | 17 48 56 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 14 25 45 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 14 31 27 | 10 | ..... | ..... | ..... | |
| N | ..... | L..... | 14 41 35 | 20 | ..... | ..... | ..... | |
| | ..... | M..... | 14 42 21 | 15 | 61 | ..... | 3,910 | |
| | ..... | F..... | 17 51 16 | ..... | ..... | ..... | ..... | |
| 23 | ..... | P..... | 7 34 05 | 5 | ..... | ..... | ..... | |
| | ..... | L..... | 7 37 09 | 10 | ..... | ..... | ..... | |
| E | ..... | M..... | 7 38 50 | 15 | ..... | 101 | 1,790 | S. California. |
| | ..... | F..... | 9 25 40 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 7 34 04 | 8 | ..... | ..... | ..... | |
| | ..... | L..... | 7 37 25 | 10 | ..... | ..... | ..... | |
| N | ..... | M..... | 7 39 01 | 16 | 82 | ..... | 1,980 | S. California. |
| | ..... | F..... | 9 26 05 | ..... | ..... | ..... | ..... | |

TABLE 3.—*Late reports (instrumental)*—Continued.

CANADA. *Dominion Meteorological Service, Victoria*—Continued.

| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* |
|---|---|---|---|---|---|---|---|
| July 26 | ..... | L..... | 3 41 04 | 10 | ..... | ..... | ..... |
| E | ..... | M..... | 3 45 29 | 12 | ..... | 1 | ..... |
| | ..... | L..... | 3 41 04 | 10 | ..... | ..... | ..... |
| N | ..... | M..... | 3 45 29 | 12 | 1 | ..... | ..... |
| 26 | ..... | P..... | ? 7 52 44 | 6 | ..... | ..... | ..... |
| E | ..... | M..... | 8 11 36 | 15 | ..... | 2 | ..... |
| | ..... | P..... | 7 52 54 | 6 | ..... | ..... | ..... |
| N | ..... | M..... | ? 8 05 44 | 20 | 1 | ..... | ..... |
| 26 | ..... | P..... | 10 10 25 | 5 | ..... | ..... | ..... |
| | ..... | S..... | 10 20 55 | 10 | ..... | ..... | ..... |
| E | ..... | L..... | 10 33 25 | 20 | ..... | ..... | ..... |
| | ..... | M..... | 10 39 45 | 20 | ..... | 1 | 9,390 |
| | ..... | F..... | 11 52 57 | ..... | ..... | ..... | ..... |
| | ..... | P..... | 10 10 25 | 5 | ..... | ..... | ..... |
| | ..... | S..... | 10 21 00 | 10 | ..... | ..... | ..... |
| N | ..... | L..... | 10 33 35 | 20 | ..... | ..... | ..... |
| | ..... | M..... | 10 39 13 | 16 | 1 | ..... | 9,490 |
| | ..... | F..... | 12 00 05 | ..... | ..... | ..... | ..... |

CANADA. *Dominion Meteorological Service, Victoria*—Continued.

| 1923. | | | *H. m. s.* | *Sec.* | μ | μ | *Km.* | |
|---|---|---|---|---|---|---|---|---|
| July 29 | ..... | P..... | 7 55 01 | 4 | ..... | ..... | ..... | |
| E | ..... | L..... | 7 55 11 | 12 | ..... | ..... | ..... | |
| | ..... | M..... | 7 56 21 | 10 | ..... | 1 | 90 | |
| | ..... | F..... | 8 00 41 | ..... | ..... | ..... | ..... | |
| | ..... | P..... | 7 55 01 | 4 | ..... | ..... | ..... | |
| | ..... | L..... | 7 55 46 | 10 | ..... | ..... | ..... | |
| N | ..... | M..... | 7 56 17 | 10 | 2 | ..... | 4,102 | |
| | ..... | F..... | 8 00 06 | ..... | ..... | ..... | ..... | |
| 31 | ..... | P..... | 5 57 11 | 5 | ..... | ..... | ..... | |
| | ..... | L..... | 5 57 15 | 8 | ..... | ..... | ..... | |
| N | ..... | M..... | 5 57 20 | 8 | 3 | ..... | 40 | E-W. H. P. being moved to new pier. |
| | ..... | F..... | 6 30 00 | ..... | ..... | ..... | ..... | |
| 31 | ..... | P..... | 15 15 35 | 5 | ..... | ..... | ..... | |
| | ..... | S..... | 15 21 39 | 8 | ..... | ..... | ..... | |
| | ..... | L..... | 15 28 30 | 10 | ..... | ..... | ..... | |
| N | ..... | M..... | 15 35 34 | 10 | 5 | ..... | 4,290 | |
| | ..... | F..... | 17 01 00 | ..... | ..... | ..... | ..... | |

(Plotted by Wilfred P. Day.)

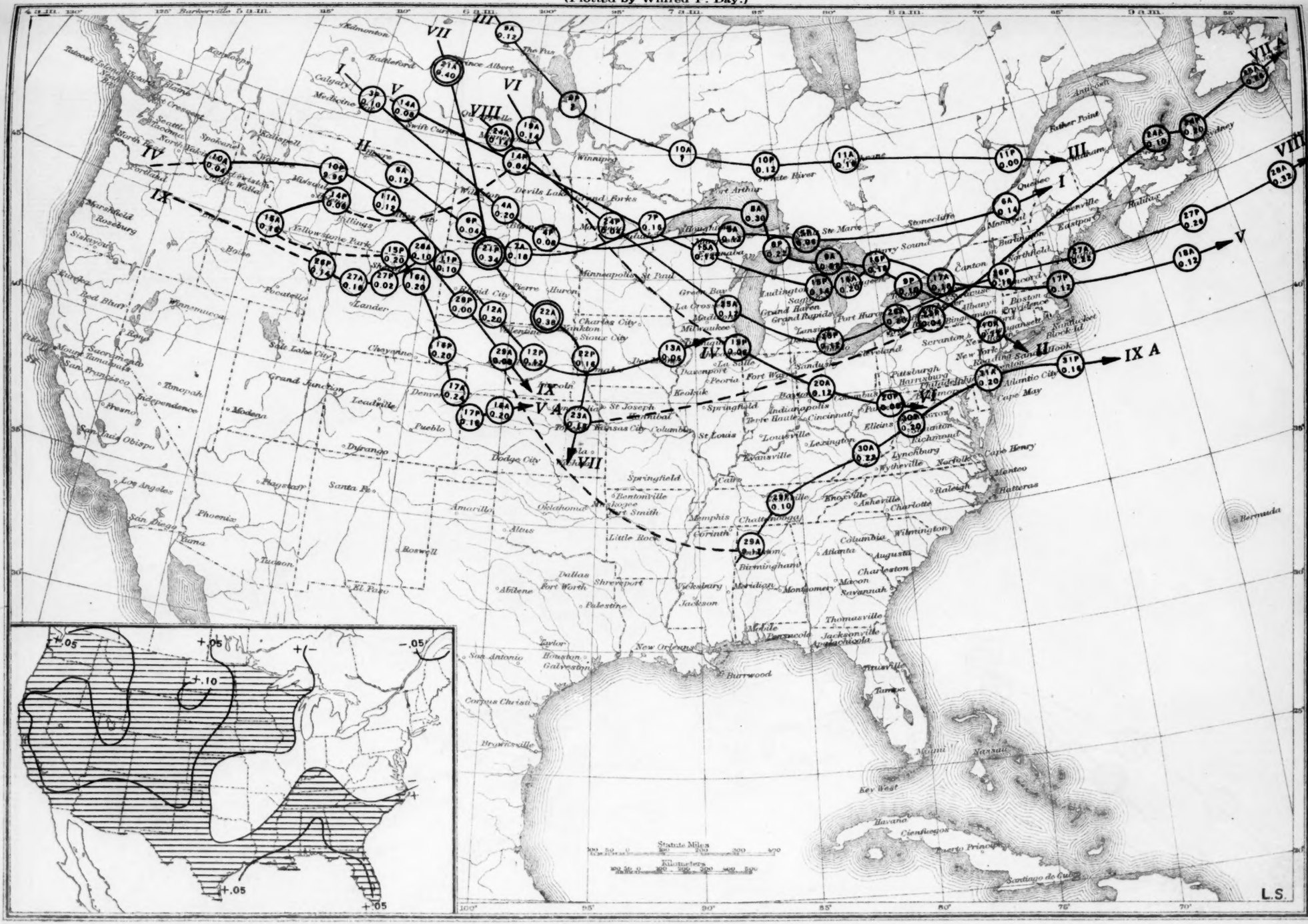


Chart II. Tracks of Centers of Cyclones, August, 1923. (Inset) Change in Mean Pressure from Preceding Month.
(Plotted by Wilfred P. Day.)

## Chart III. Departure (°F.) of the Mean Temperature from the Normal, August, 1923.

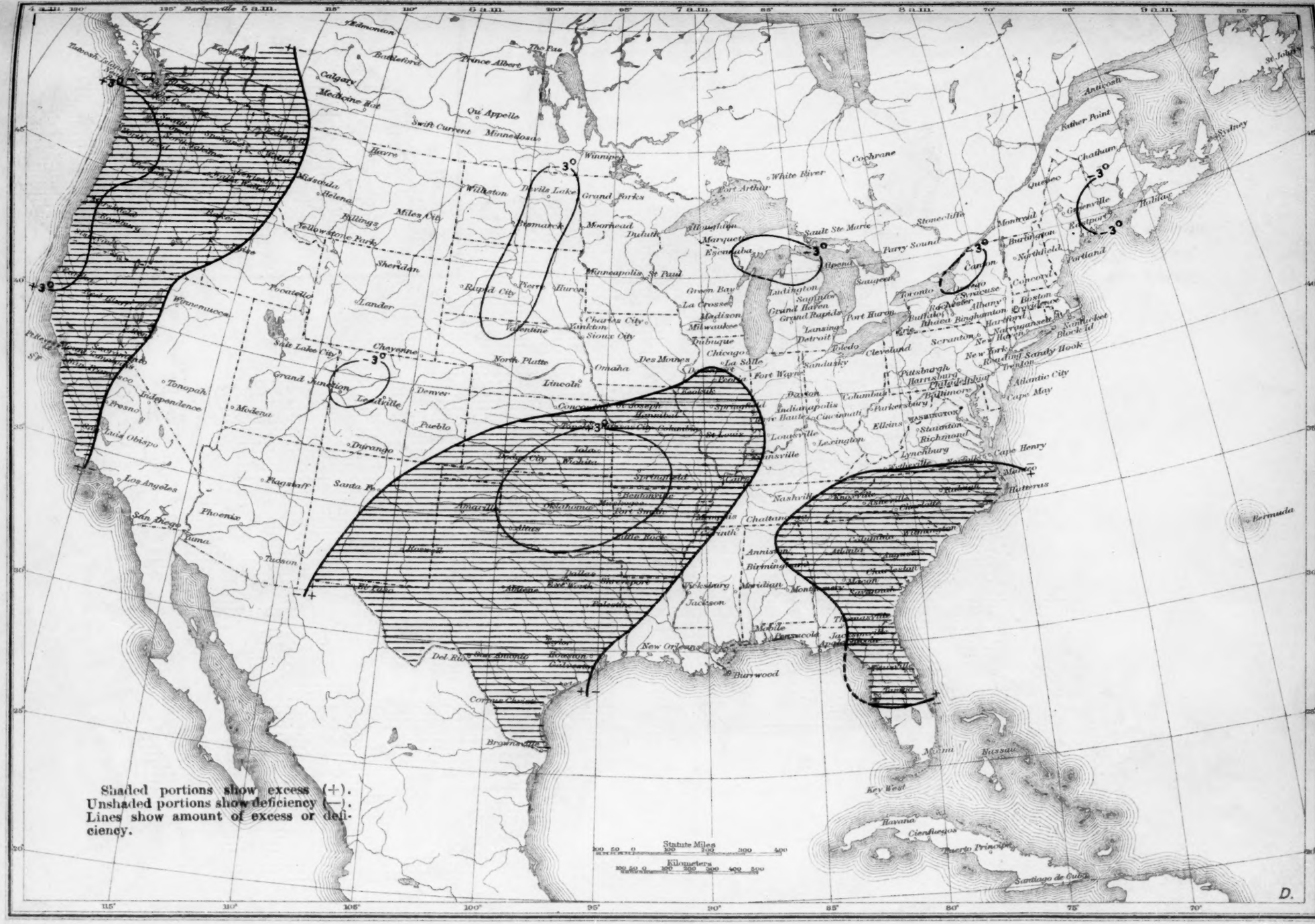


**Chart IV. Total Precipitation, Inches, August, 1923.** (Inset) **Departure of Precipitation from Normal.**

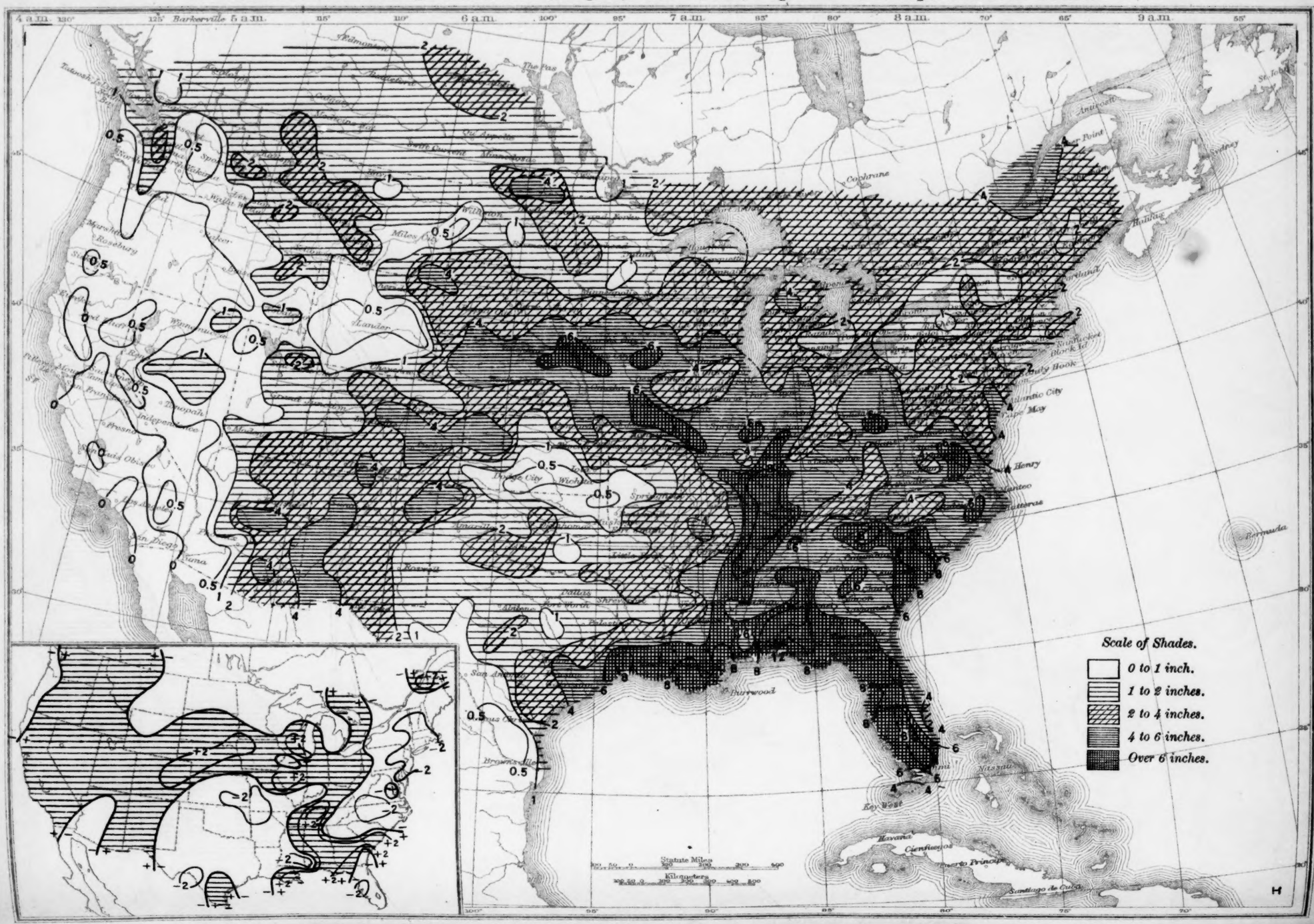





**Chart V. Percentage of Clear Sky between Sunrise and Sunset, August, 1923.**

Chart V. Percentage of Clear Sky between Sunrise and Sunset, August, 1923.

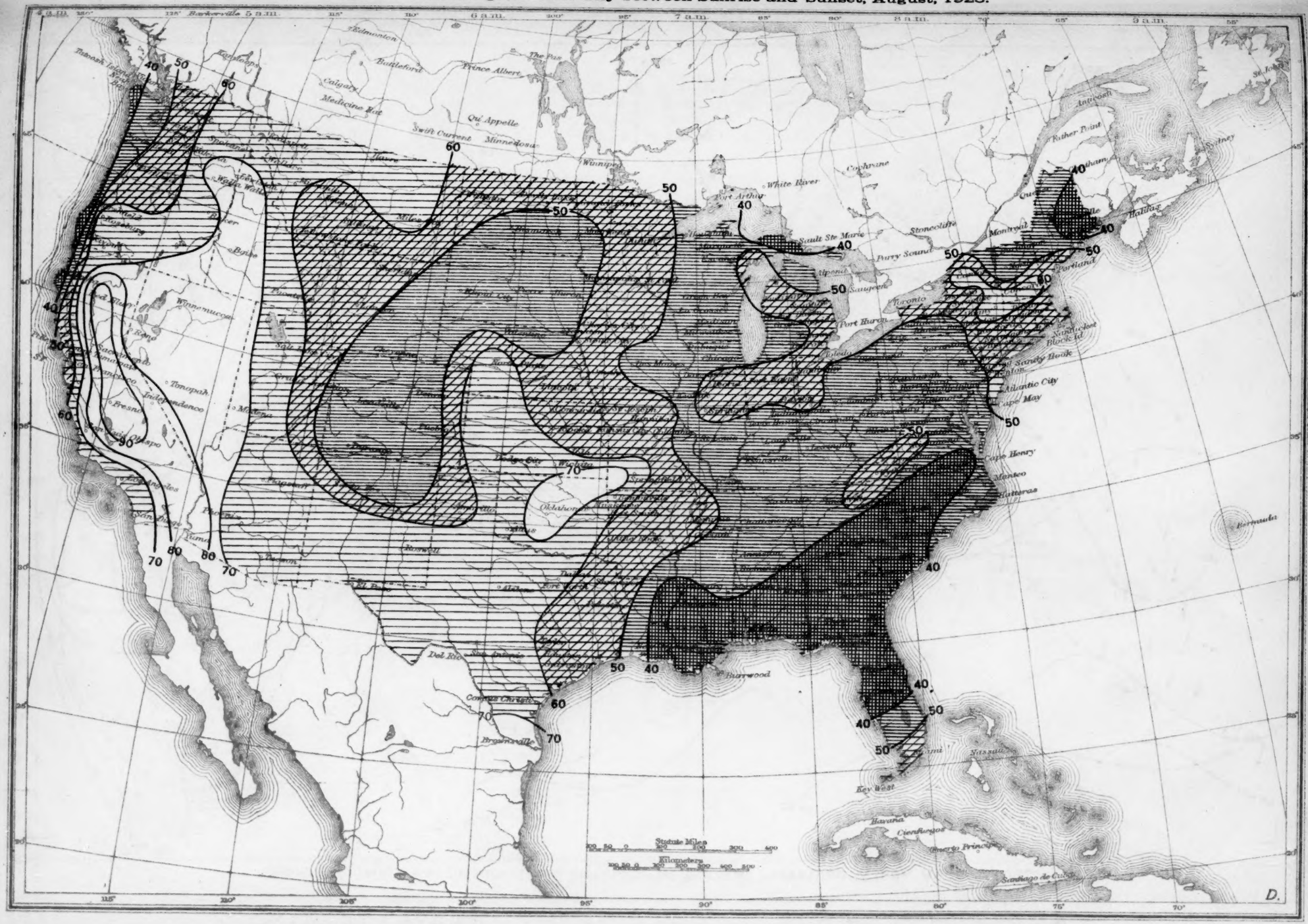
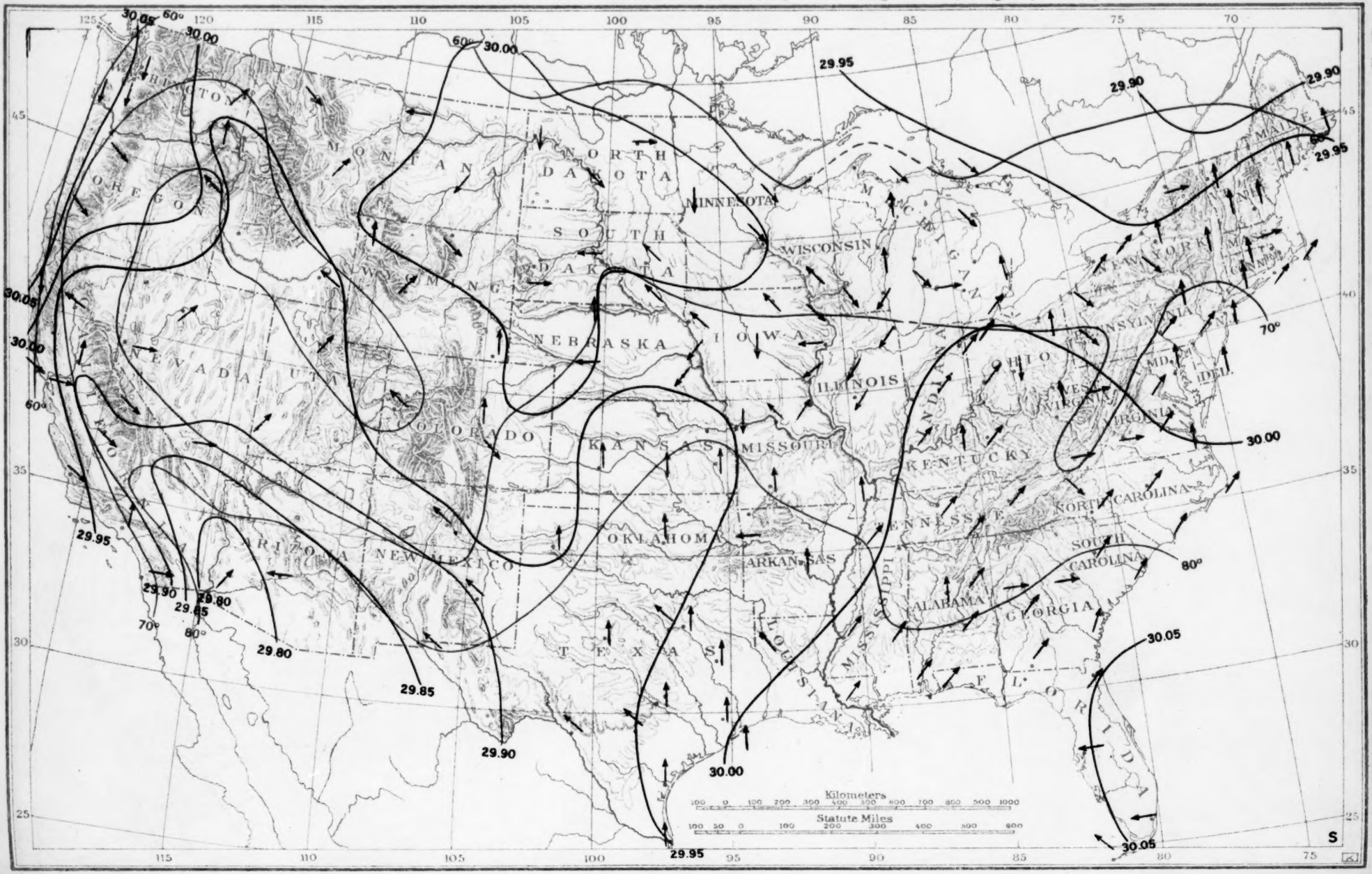


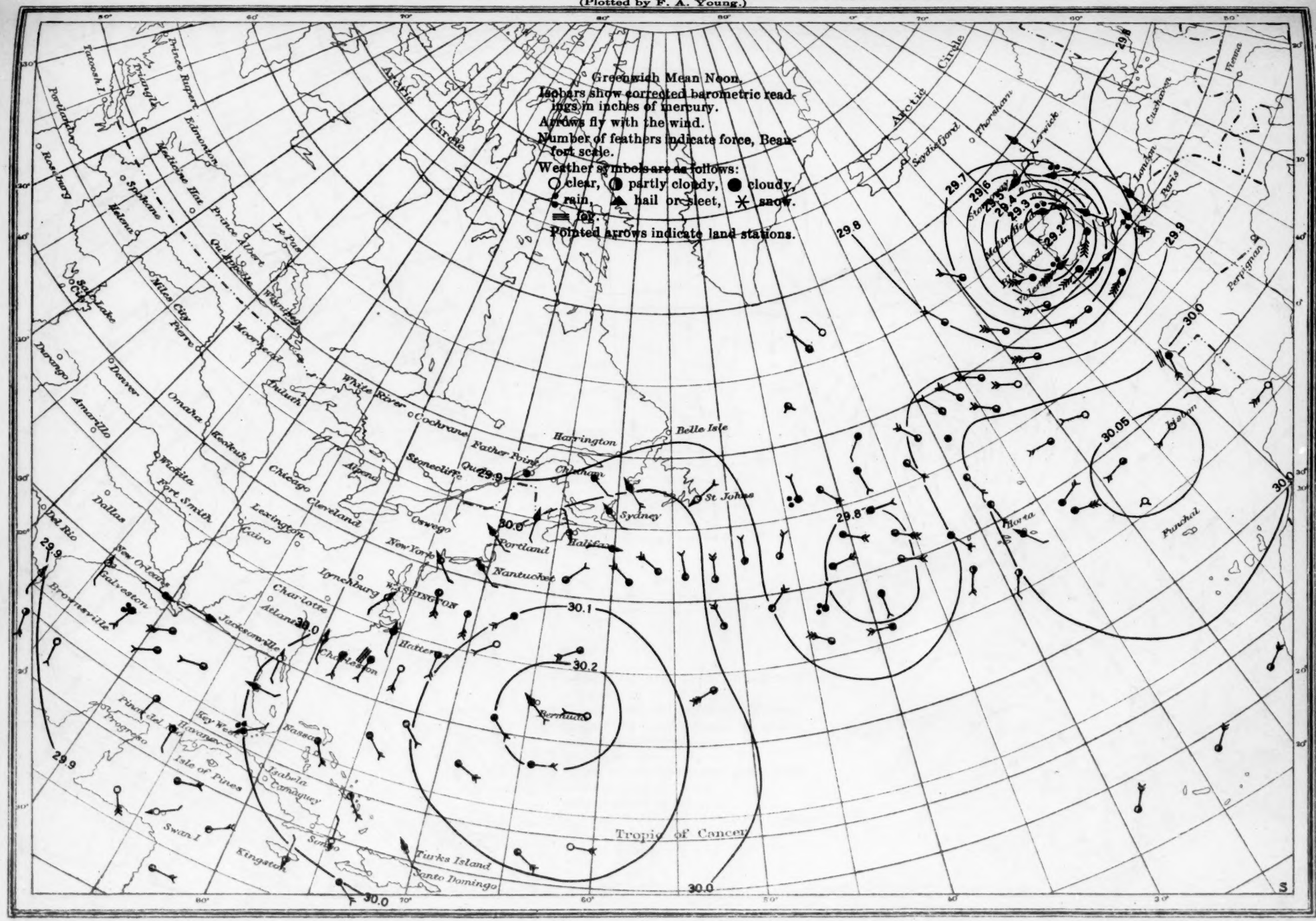
**Chart VI. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, August, 1923.**






(Plotted by F. A. Young.)

(Plotted by F. A. Young.)



## Chart IX. Weather Map of North Atlantic Ocean, August 3, 1923.

(Plotted by F. A. Young.)

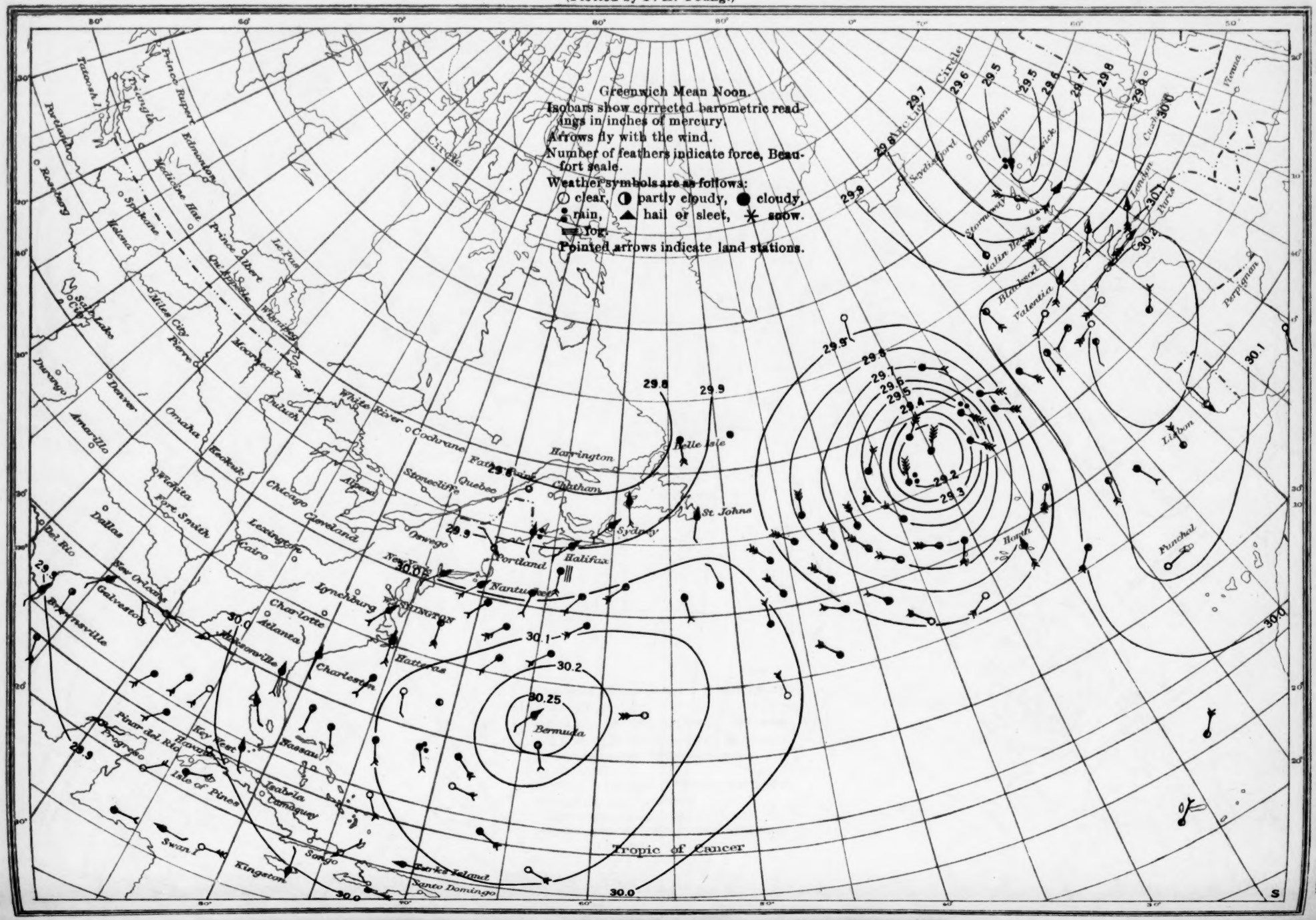


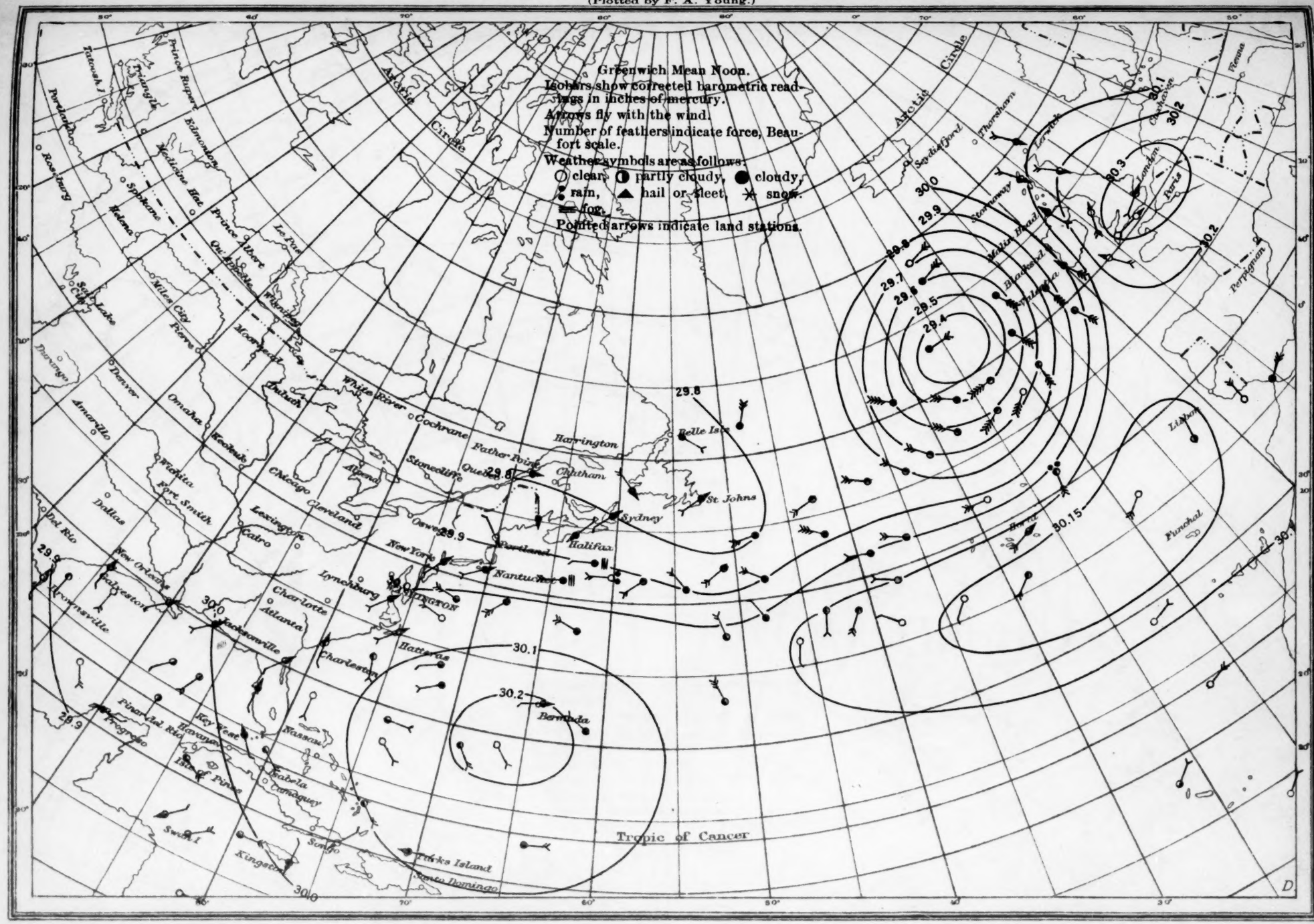


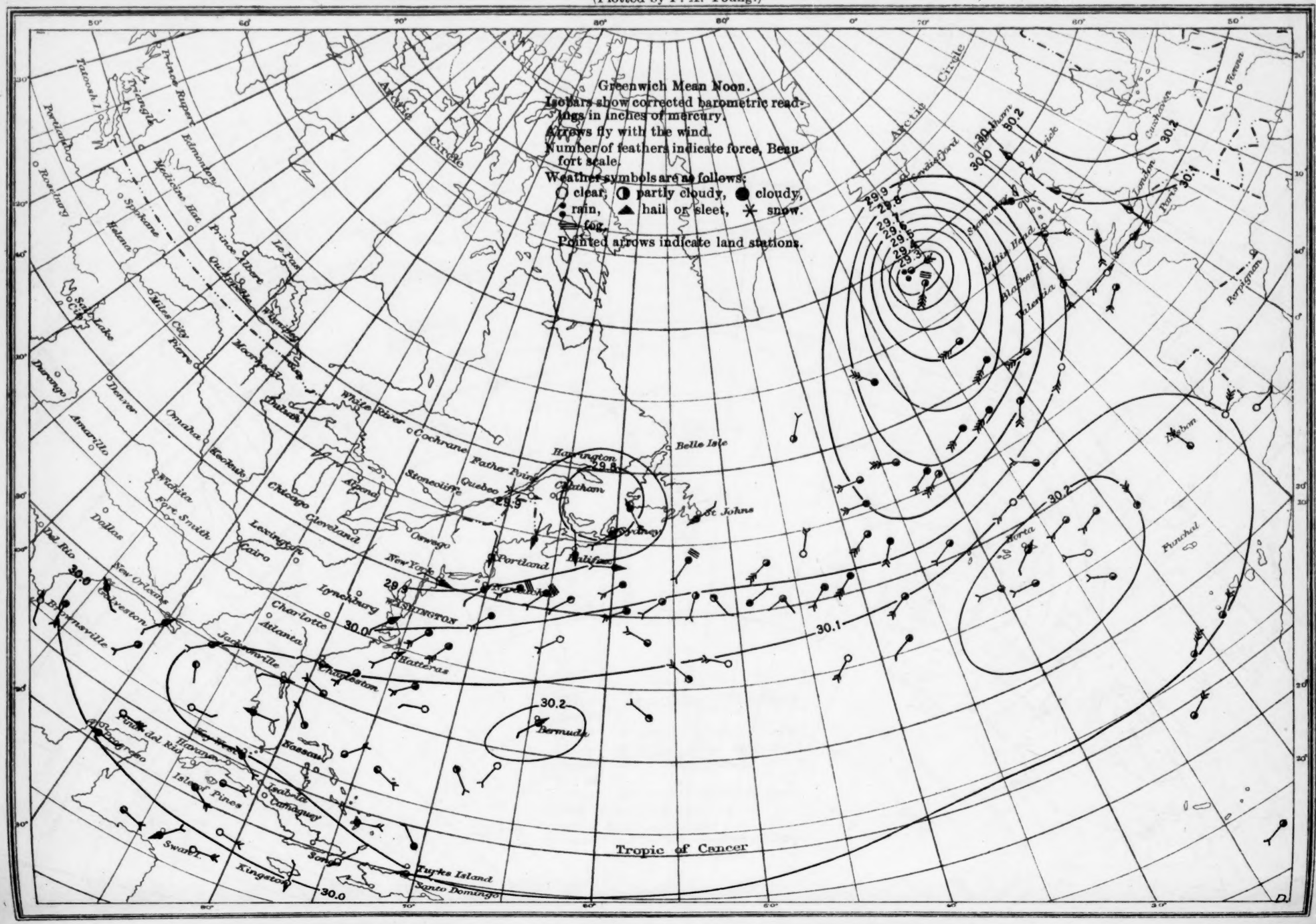

Chart X. Weather Map of North Atlantic Ocean, August 4, 1923.

(Plotted by F. A. Young.)

Chart X. Weather Map of North Atlantic Ocean, August 4, 1923.

(Plotted by F. A. Young.)



## Chart XI. Weather Map of North Atlantic Ocean, August 5, 1923.

(Plotted by F. A. Young.)